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Interactive graphical support for a small-unit amphibious operation combat model.

Simon, Glenn D.

Monterey, California. Naval Postgraduate School

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Monterey, California

THESIS

INTERACTIVE GRAPHICAL SUPPORT
FOR
A SMALL-UNIT AMPHIBIOUS OPERATION
COMBAT MODEL

by

Glenn D. Simon

March 1983

Thesis Advisor: J. G. Taylor

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(1) line graph; (2) bar chart; and (3) grid map. Each type provides a different view of the model's output data. By utilizing these types of visual displays, the viewer is provided a supportive method that enables him to analyze and assimulate the model and its output data.

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Interactive Graphical Support
for
A Small-Unit Amphibious Operation Combat Model

by

Glenn D. Simon
Major, United States Marine Corps
B.A., Lamar University, 1970

Submitted in partial fulfillment of the
requirements for the degree of

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ABSTRACT

The scope of this thesis is to take a first step towards making a combat model "user friendly" through interactive computer graphics. To accomplish this first step a graphical support program was developed for visual/graphical representation of a Lanchester-type force-on-force combat model that simulates a small-unit amphibious operation. The graphical support program provides the user with a menu to determine the type of visual display for output data. Three types of visual displays are considered: (1) line graph; (2) bar chart; and (3) grid map. Each type provides a different view of the model's output data. By utilizing these types of visual displays, the viewer is provided a supportive method that enables him to analyze and assimulate the model and its output data.

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I. INTRODUCTION

A. OVERVIEW

This thesis develops an interactive upgrade and an interactive graphical support program which is the main thrust of the thesis for a small-unit amphibious operation combat model developed by James M. Crites [Ref. 1]. He states the overview of the model as follows:

> "The model commences with a ship-to-shore assault of aggressor forces (e.g., a U.S. Marine Infantry Battalion), mounted onboard Landing Vehicle Assault craft (LVA) moving against a defensive force ashore located in fixed position along the coast the aggressor force is attempting to occupy. Once the ship-to-shore phase of combat is completed, the model continues to simulate land combat further inland between the assaulting aggressor forces and other defensive forces occupying key terrain." [Ref. 2: p. 10]

The interactive upgrade of the model provides the user the capability to interact with the time step interval and the type of output for each phase of the model. The main thrust of the thesis is to support the model with a variety of visual displays to facilitate the understanding and assimulating of both the output data of the model and the model itself.

B. SMALL-UNIT AMPHIBIOUS OPERATION COMBAT MODEL

1. Background

The small-unit amphibious operation combat model has been the result of an evolutionary process. This process was initiated by David L. Chadwick in his thesis [Ref. 3]. He modeled the amphibious assault of five waves of LVA against a defensive force composed of tanks and antitank

guided missiles (ATGM) in fixed positions ashore. Additionally, a land combat model has been developed by Joseph Smoler in his thesis [Ref. 4] which modeled three aggressor force units utilizing tanks and attacking three defensive force units armed with tube launched, optically tracked, wire command link guided missile systems (TOW) in fixed positions. Smoler's model utilizes the Fulda Gap region of West Germany as the location for the land combat. The land combat model was further enhanced by Glenn Mills in his thesis [Ref. 5] which added flexibility to Smoler's model. With an amphibious assault and land combat models developed, the next step in the process was to develop a model which combined the concepts of the two models into one which simulates an amphibious assault. Soon Dae Park in his thesis [Ref. 6] integrated the two models into a small-unit amphibious warfare model. Park's model served as the basis for the next evolution which is the present configuration of the model.

2. Present Configuration

The present configuration of the model is found in Crites' thesis identified in Reference 1. In his thesis the small-unit amphibious operation combat model consists of two distinct, yet interrelated phases. The first phase is the ship-to-shore combat phase which depicts an aggressor force of five waves of LVA's against a defensive force of one tank and one ATGM unit in fixed locations. The second phase is the land combat phase where two forces which consist of three aggressor units of tanks and three defensive units of TOW's battle each other in the Fulda Gap area of West Germany. The interrelation of the two phases results from the concept of an amphibious assault which begins at sea and ends with the accomplishment of a land objective(s). Since the Fulda Gap area is of grave importance to military

commanders, it is only fitting that this area be utilized to provide the field of battle during the land combat phase. The battle outcome of both phases and the initial input data are presented in an alphanumeric listing titled "Amphib1 Listing". This listing and the previously discussed phases of the model are the departure point for the thesis.

C. GOALS OF THE THESIS

There are three goals of the thesis. The first goal is to develop an interactive upgrade of the model that provides the appropriate data management for interaction of the model with the graphical support. The second goal is to develop an interactive graphical support package that provides visual displays of the data output of the model. The final goal is to develop an executive routine that interfaces the model with the graphical support program. Before discussing these goals an understanding of what is interactive computer graphics is necessary.

II. GENERAL DISCUSSION OF COMPUTER GRAPHICS

A. BACKGROUND

Computer graphics first entered into the computer field in 1960 when a computer-driven display was attached to MIT's Whirlwind I [Ref. 7] computer to generate simple pictures. The computer-driven display made use of the cathode-ray tube (CRT). This CRT was similar in design to the one used in television sets. Even with this utilization of the CRT, the progress of interactive computer graphics was stifled because of the actual employment of the computer in the 1950's. The computer was basically utilized by scientists and engineers as "number crunchers". Not until MIT developed the TX-0 and TX-2 did interactive computer graphics become feasible, thus laying the foundation for an academic explosion in this field of computer utilization [Ref. 8].

With the new developments at MIT in the feild of computer graphics, the stage was set for a new computer language to facilitate the user in expressing his ideas. In 1957, a new computer language was developed by J. W. Backus and associates which was introduced by IBM and called FORTRAN [Ref. 9]. The design of the language centers around a single primary goal: execution efficiency. Even though FORTRAN provided users with a more efficient means of communicating with the computer, it was not unitl the early 1960's that people started to realize that a more interactive method of communication with the computer must be developed. Thus, interest in graphical displays began to grow.

A dissertation in 1963 by Ivan Sutherland discussing his Sketchpad system provided the breakthrough in utilizing interactive graphical displays [Ref. 10]. Sketchpad system comprised of programs which used an interactive display console that responded as an input/output device. This device accepted and displayed data in both pictorial and alphanumeric characters and also provided a more efficient means of controlling the program's sequence. By the mid-1960's Sutherland had seen his Sketchpad system take on may changes, and in the area of graphical research a number of companies had initiated research projects. In the 1970's the fruit of these research projects was felt. During the early 1970's many airline carriers installed on-line terminal systems to expedite the processing of passengers. With the advent of the home computer and video games, interactive computer graphics has established itself as a viable field within the computer world.

B. DESIGN PRINCIPLES

When designing an interactive computer system or program, it is only fitting that certain general design principles be considered. The principles that are relavent to an interactive graphical program are [Ref. 11] :

1. Self-explanatory.
2. Self-helping (help user).
3. Simple interface with user.
4. Interaction by anticipation.
5. Optional verbosity.

A self-explanatory program is one which displays to the user sufficient explanatory information of the process being

carried out to alleviate the user from having to use external manuals for explanations. This can be satisfied by the designer by having his program display certain items that are essential to the understanding of the program's process. These items could be of the form of an introduction, a menu, messages, or reminders displayed on the CRT.

A self-helping program provides a friendly atmosphere which does diagnostic checking of the input to the program. When the user inputs an item outside the bounds of the query, the program returns a diagnostic message stating the fallacy of the input item. After the message is sent, the program requeries the user and awaits further input.

Simple interfacing with the user is facilitated by ensuring that short, simple and obvious actions are required of the user. The presenting of a menu where the user selects an option of the program could be one form of interfacing. It is recommended that each menu be comprised of groups of options from five to seven selections. By limiting the menu selections to the above numbers, the user is better able to assimulate the information and is not over burdened by the amount of information presented.

An extremely beneficial and desirable feature of a program is interaction by anticipation. Interaction by anticipation means that the program is designed to anticipate the desires of the user. These desires are presented within the options of the program. A menu selection method provides the options with their numerical values from which a user would select his desired option by entering the number corresponding to his choice. By streamlining the program in this manner, the user is not required to enter a lengthy line of input in order to manipulate the program.

The final principle, optional verbosity, can be described as a program with two levels of detail. One level for the novice or first-time user will contain detailed

information concerning the program and the actions required of the user. Whereas, the other level will provide little or no information and abbreviated communications both to and from the computer program. The type of terminal that is being used will determine the amount or lack thereof of optional verbosity.

The design principles above provide a foundation for the development of an interactive graphical program. At this concourse in the thesis a discussion about the principles of chart and graph design is pertinent.

C. PRINCIPLES OF CHART DESIGN

Charts and graphs provide a medium for explaining, interpreting and analyzing numerical facts by means of points, lines, areas and other geometric forms and symbols. They present a form of visual communication which presents a more clearly grasped and more easily remembered representation of quantitative data. Charts and graphs can help visualize hidden facts and relationships, as well as provide a comprehensive picture of a problem. They alone are not the total substitute for presentation of data, but they should be used in conjunction with tabular forms and other forms of presentation [Ref. 12].

The design and layout of charts and graphs are governed by certain basic principles. The designer should first become famaliar with the type of data to be presented in graphic form. He must digest the material and become aware of the major implications associated with the material. Along these lines the designer should focus on the methods that are utilized to produce the data and an understanding of the subject matter which produced the data. Secondly a decision concerning the type of chart or graph that will appropriately represent the data is made. There are several

factors which enter into a decision of this kind, such as [Ref. 13] :

1. Nature of the data.
2. Medium of presentation.
3. Purpose of the chart.
4. Time available for preparation.
5. Audience for whom the chart or graph is intended.

The first factor, nature of the data, has the designer focusing upon the data itself. Some forms of data do not lend themselves to graphical representation, thereby utilizing a form of a table to present the data. If the data are classified by some form of geographical category, the designer could present the data in the form of a map to illustrate the geographical categories. For time series data the designer is able to select from a variety of charts for representation of the data. Once the nature of the data has been determined and a decision on the type of chart or graph to design, the designer must now consider the medium of presentation of the chart or graph.

The medium of presentation relates to the useage of the chart or graph. Charts or graphs may be used in a number of ways. Some of these ways are for reproduction in books, reports, papers or any other form of typewritten work, lectures, slides, and other forms of media. Since there is such a vast array of mediums of presentations, the designer must consider the possibility of reproduction, the type of reproduction, and the amount of reduction of his design. The areas where his concern are focused on are the overall size of the chart, thickness of lines, size and style of lettering, the positioning of the lettering and a variety of

other details of the chart or graph. Along with considering the medium of presentation the designer must also consider the purpose of the chart or graph.

In conjunction with the purpose of the chart the designer must ensure that his design fulfills certain basic objectives. Schmid [Ref. 14] listed the following basic objectives:

1. Accurate representations of the facts.
2. Clear, easily read, and understood.
3. So designed and constructed as to attract and hold attention.

Along with the above basic objectives each chart or graph is designed with one or more specific objective(s). The designer must constantly remind himself of the objective(s) of his chart or graph so that he does not loose sight of the purpose of his design.

Another factor that the designer must be aware of is the time available for preparation. A designer could become unduly concerned with the time element and cost of a project causing his work to be hurried and sloppy. If he indulges in useless details, he could waste time and clutter the design with non-essential information. By planning his time and covering the subject adequately, the designer is able to produce a work of high quality.

The final factor that a designer must consider is the audience to whom the chart or graph is intented. The designer is concerned with the technical knowledge of the audience in the realm of graphics presentation. The technical knowledge of his audience will determine the type and detail required in his design.

In this and the previous section a discussion of the principles behind interactive computer graphics and chart design have been provided to illuminate the thrust of this thesis.

III. SMALL-UNIT AMPHIBIOUS OPERATION COMBAT MODEL UPGRADE

A. OVERVIEW

The small-unit amphibious operation combat model presently consists of two combat phases of an amphibious assault. Figure 3-1 in Crites' thesis provides the scheme of the flow and sequence of events for the model. Within the sequence of events is depicted two submodels which comprise the overall model. The ship-to-shore combat submodel handles the amphibious operation from a distance of twenty-five miles at sea to the shore. The land combat submodel handles the battle once the aggressor forces have reached shore and started their land assault. The sequence of events for the two submodels are found in Figures 3-3 and 3-7 in the above reference. Each submodel has its own input data file. For the ship-to-shore combat submodel the input data file SEA1 DATA and for the land combat submodel the input data file LAND DATA are used (See Appendix B). Since this thesis was a first step towards making this combat model "user friendly", the author felt that the development of the interactive graphical support should be a separate program. This decision of maintaining separate programs (e.g. the small-unit amphibious operation combat model and the interactive graphical support programs) lead to a redefining of the data management within the model's program and developing an executive program to execute the two programs. The data management is discussed in the next section, whereas the executive program is discussed in Chapter V of this thesis.

B. DATA MANAGEMENT

The data management within the model consisted of the employment of arrays to store the input and processed data during the execution of the model. With the development of the interactive graphical support program, the management of the data transfer between the support program and the model's program had to be accomplished within the constraints of the FORTRAN language [Ref. 15] and the method of storage in the IBM 3033. Once the appropriate data were processed and stored within the combat model, the next step was to transfer the data from the model's program to files established on magnetic disk by the executive program (See Appendix C). This transfer was accomplished by adding various write statements within the model's program. To transfer the data from the files to the support program and place the data within the appropriate data structures, a special subprogram titled Input was developed to handle these functions (See Appendix A). The data structures utilized in the support program paralleled those used in the model: arrays. Having established the data structure and management for the thesis, the next step was to determine which input data varaibles of the model were candidates for being entered interactively.

C. ITERACTIVE FEATURES

There were two input data variables of the model that were candidates for restructuring as interactive inputs by the user. Within the area of data output it was felt that the user should be allowed to interactively select the detail of the battle summary that he desired. The model's program was upgraded by providing a menu from which the user would select the desired detail of the battle summary (See Appendix A). The other feature selected was the time step

which determines the interval that the model utilizes for each iteration. The time step is presently hard wired in at ten second intervals. This static interval does not provide the flexibility for the user to effectively analyze the data. Therefore, the time step was changed to an interactive item allowing the user the opportunity to input the interval for analyzing the data over. Although there are a number of other candidates within the model's program for transistion, these two input data variables were selected due to the time element not being sufficient to convert all of the possible candidates.

IV. INTERACTIVE GRAPHICAL SUPPORT DESIGN

A. OVERVIEW

The interactive graphical support for a small-unit amphibious operation combat model consists of a main program and five subprograms. The main program uses subroutines to input the data generated from the execution of the small-unit amphibious operation combat model, to initialize the data for further use within the program, and to guide the user toward the graphical display of the data. The main program consists of five features which perform its functions. The first feature is the data handling feature which manipulates the data by inputting, storing and initializing. This feature handles this process by calling two subroutines within the support program. The second feature of the support program is the interactive feature which interacts with the user regarding the selection process dealing with the introduction and graphics representation of the model's output data. The third, fourth and fifth features of the support program contain the appropriate FORTRAN subroutines for producing line graphs, bar charts and a grid map. The latter three features are independent of the other, but they depend upon the selection process of the interactive feature. Figure 4.1 describes the method for the flow and sequence of events in the main program. As previously mentioned each feature of the support program has its own unique purpose, and a detail elaboration of each feature will be presented so that the reader can appreciate the contribution of each feature to the overall support program. Before beginning the discussion of these features, it is pertinent at this point to present to the reader an

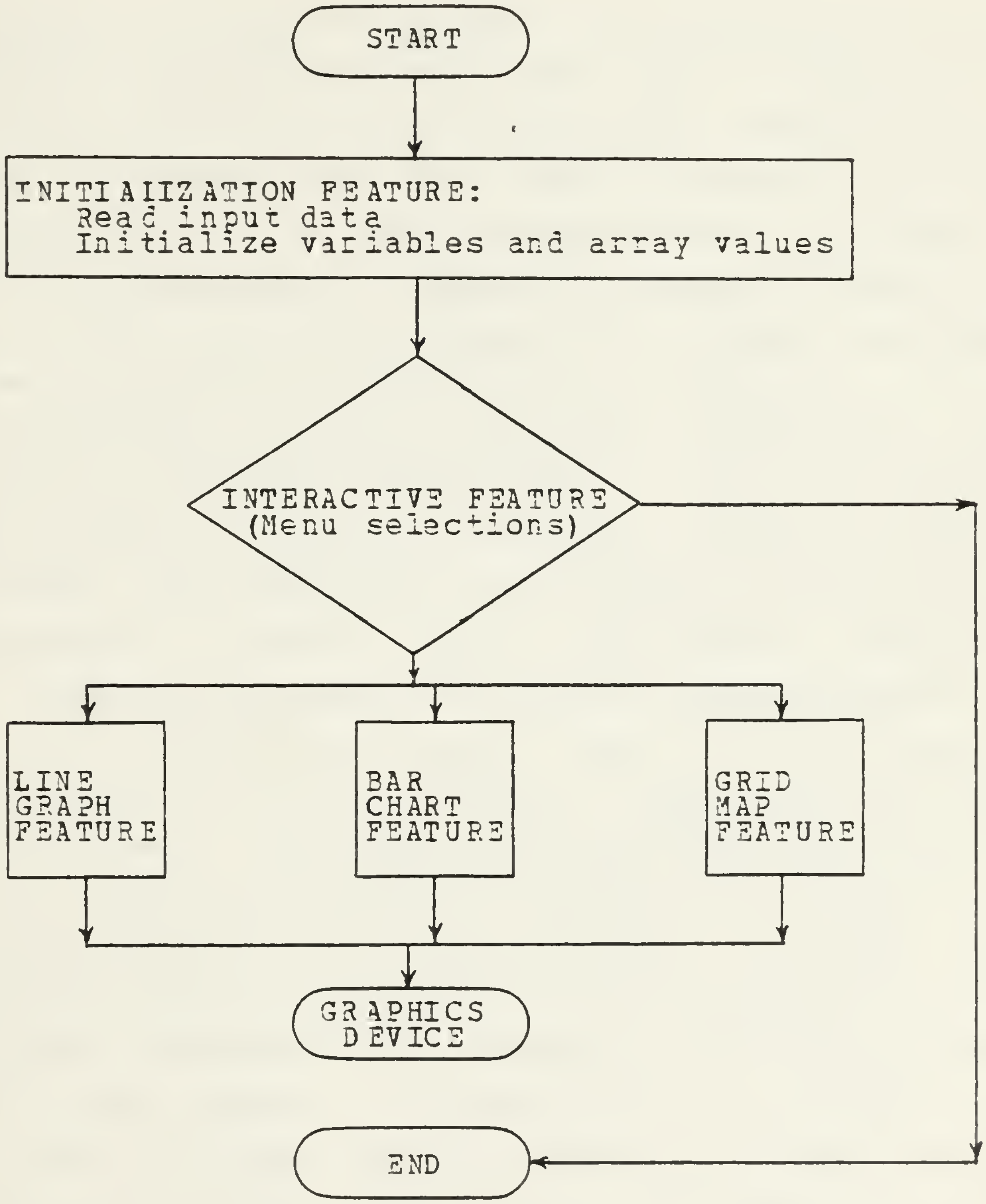


Figure 4.1 Sequence of Events in the Main Program.

explanation of the software utilized in developing the last three features.

B. DISSPLA

The software utilized to develop the last three features of the support program is DISSPLA [Ref. 16]. DISSPLA is an acronym which stand for Display Integrated Software System and Plotting LAanguage with the capital letters making up the acronym. It is a proprietary software product of Integrated Software System Corporation (ISSCO). DISSPLA is written in the computer language of FORTRAN utilizing subroutines as the basic foundation of the software. It is computer independent in that it has been designed for both the mainframe and super-minicomputers. It is also device independent enabling the user to utilize different graphics output devices. The selection of the graphics output device is determined by a single call to the device nomination routine. DISSPLA provides many levels of sophistication to the user. It can produce simple, quick or high quality, professional plots with the degree of sophistication controlled by the user. To effectively use DISSPLA all that is needed is a basic knowledge of FORTRAN and access to a pocket guide [Ref. 17] or user's manual. Another book titled "DISSPLA First Facts" [Ref. 18] is benefical to the first time user beacause it illustrates the different types of graphics and levels of sophistication available in DISSPLA. With an idea of the software utilized in this thesis, let us now take a look at the five features of the interactive graphical support program.

C. DATA HANDLING FEATURE

The data handling feature is the first feature employed within the main program. This feature is imperceptible to the user; since he is unaware of the execution of the functions of this feature. This feature provides for the inputting, storing and initializing of the data generated by the combat model. It handles its functions by the use of two subroutines within the support program. The Input subroutine acquires the generated data of the combat model from the disk space and stores the data into the appropriate arrays and variables. The Inital subroutine determines if the attrition data are too voluminous for use in the line graphs, and if so, transistions the attrition data by a sequential, deterministic process into a smaller attrition data base. Upon the termination of the functions of this feature, the main program is ready to begin interfacing with the user.

D. INTERACTIVE FEATURE

The interactive feature of the main program is the first feature that the user encounters. This feature is the work horse of the program providing the interface with the user, querying the user for and maintaining his selections, and guiding the user through various menus culminating with the entrance into one of the other features (i.e. line graph, bar chart, or grid map). This feature is designed around the principles of simple interfacing and interaction by anticipation. Simple interfacing is accomplished by requiring the user to respond only to the queries by either a simple press of the "enter" key on the keyboard, or by typing in the numerical value of the menu's option or of the input data variable requested. As for interaction by anticipation, it is accomplished by providing the user with a

menu selection process which anticipates his desires in reaching the goal of graphical representation of the model's output data. Figure 4.2 illustrates the sequencing of the menus within the support program. Appendix A, user's manual, provides a more detailed explaination of each menu in Figure 4-2.

E. LINE GRAPH FEATURE

The next feature within the main program is the line graph feature. The purpose of this feature is to construct a graphical representation of the attrition data of the forces employed within the two combat phases of the small-unit amphibious operation combat model. The attrition data utilized in the line graph represent the percentage of a unit remaining during the execution of combat. The association between the attrition data and the time step used in the combat model is depicted by the connected data points displayed in the line graph. The line graph also illustrates the depletion of the unit's strength per time step as the combat progresses. Thus, the line graph correlates the percentage of units remaining with the numerical value of the unit at each time step. The x-axis of the line graph is labelled with the time step while the y-axis is dual labelled with the percentage of unit(s) remaining and with the strength of the unit. The time step intervals on the x-axis may not coincide with the time step interval selected by the user in the combat model. The reason for this difference is due to the limited space associated with the subplot area in relation to the overall page size of the plot. To circumvent this problem the subroutine, Inital, utilizes a deterministic method to calculate a proportional time step scale for the x-axis. In conjunction with determining this time step scale, the subroutine must also

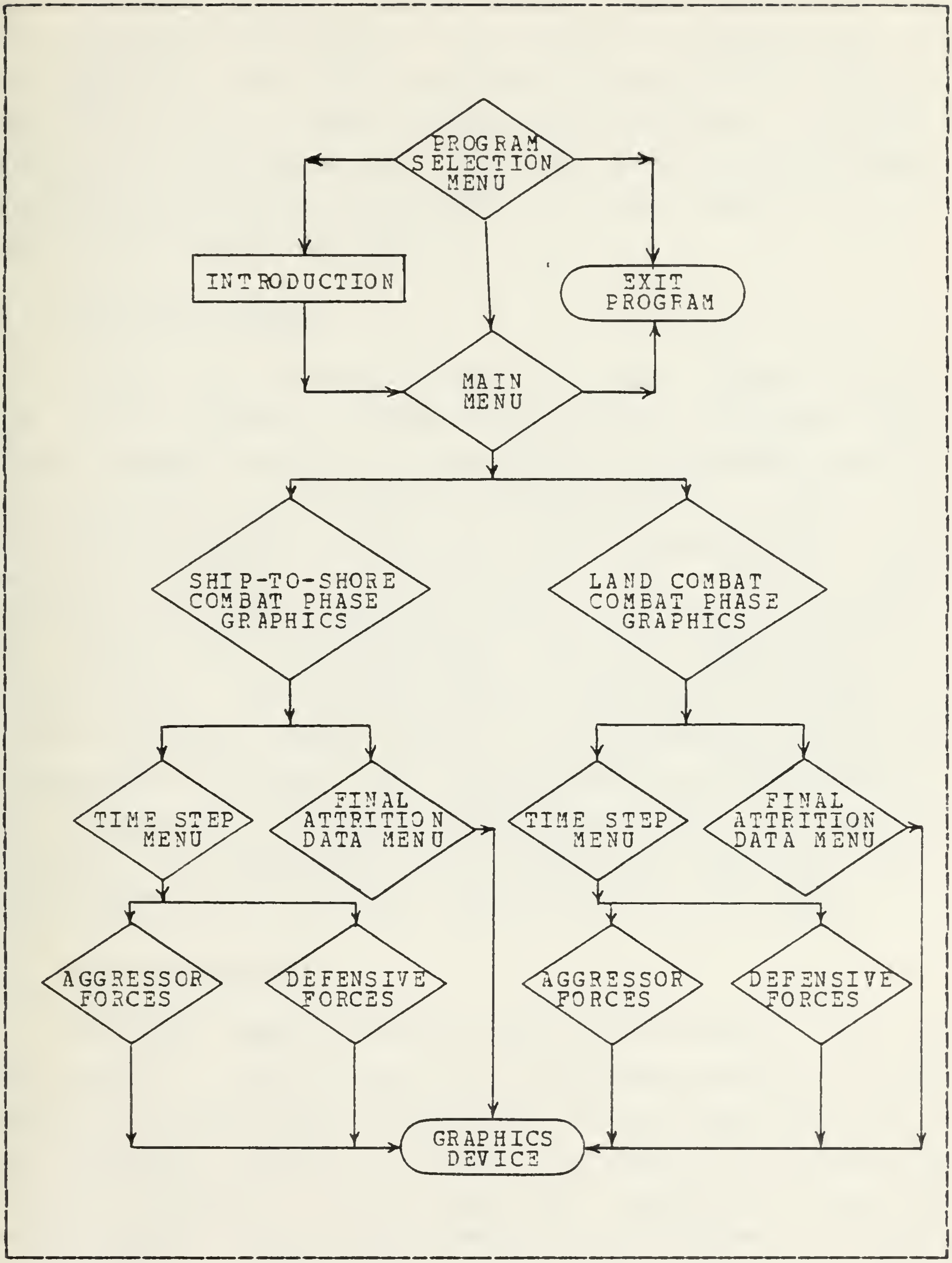


Figure 4.2 Menu Sequence in Support Program.

systematically select the percentage value assoicated with the new time step scale. This is done to approximate the original line that would have been drawn had all the data been able to be plotted. With the line graph the user is able to visually acquire what the data in the AMPHIB1 LISTING is telling him about the attrition effect on a unit during an amphibious operation.

F. BAR CHART FEATURE

The bar chart feature within the main program depicts the final attrition status of a group of forces within either combat phases of the small-unit amphibious operation combat model. A group of forces relates to either the aggressor or defensive force in either combat phase. Upon selection of the group of forces, the graphics device displays a bar chart with the name of the units as labels on the x-axis and the percentage of force remaining as the y-axis label. The purpose of the bar chart is to give the user a graphical representation of the status of forces upon termination of combat. So, if the user is not interested in the attrition of force(s) per time step, the user is provided the opportunity to utilize the bar chart as a representation of the final attrition data of a force.

G. GRID MAP FEATURE

The final feature within the main program is the grid map feature. The grid map is a coordinate scale map which covers a ten kilometer square area of the Fulda Gap area in West Germany. Figure 4.3 presents the area of the Fulda Gap that is modeled by the small-unit amphibious operation combat model. The grid map feature was developed to present a graphical representation of the locations of the units, primary and alternate firing positions of the defensive

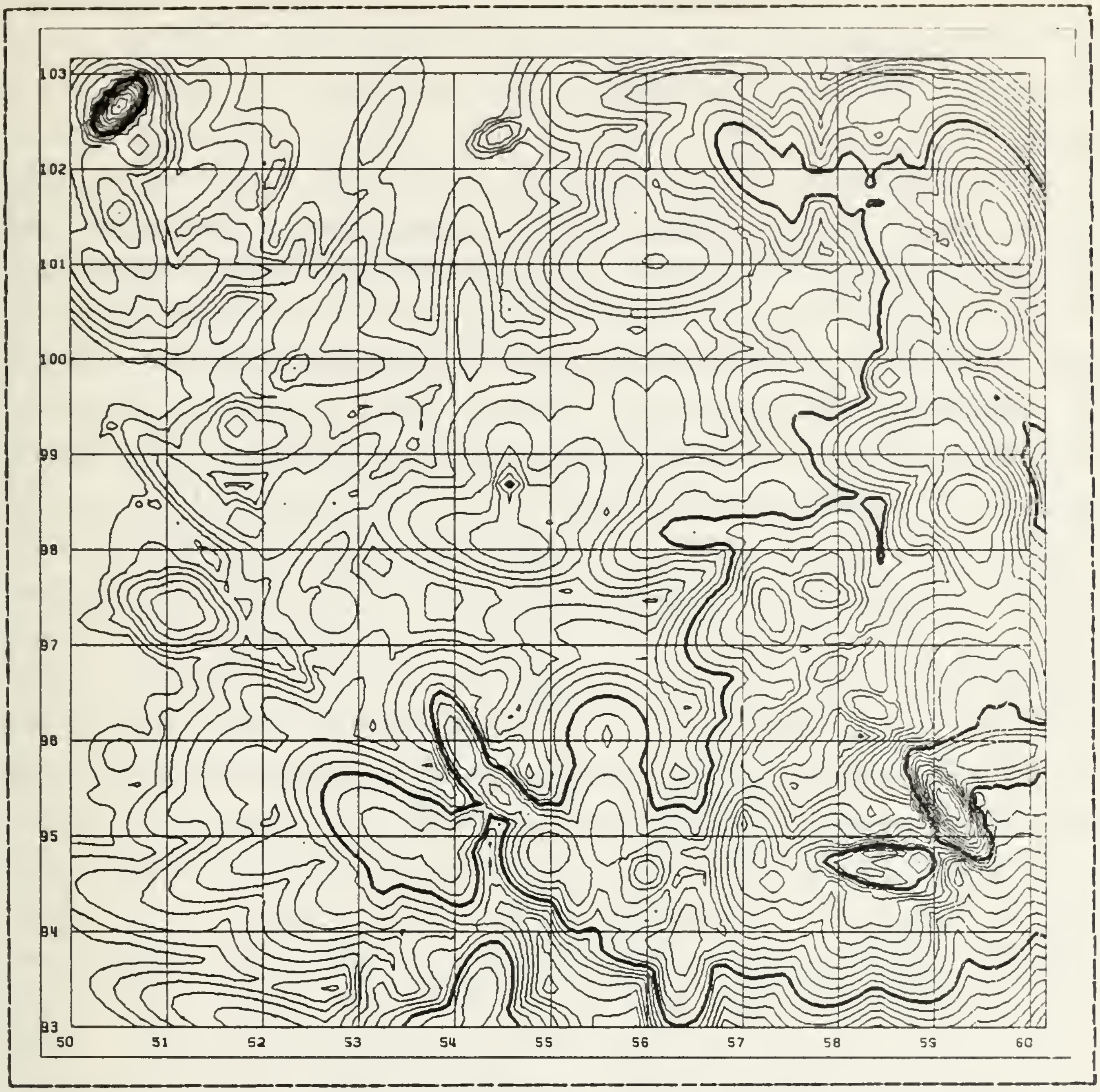


Figure 4.3 Fulda Gap Area of West Germany.

forces, and avenues of approach of the aggressor forces in the land combat phase of the model. The only drawback of the grid map at the present is that it does not display the contour lines of the Fulda Gap area which is beyond the scope of this thesis, but with some research and time the displaying of the contour lines could be incorporated into

the grid map feature. The grid map has two sets of coordinates on it. The first set is the set utilized within the combat model to determine the location of forces, line-of-sight between forces, and location and height of hills within the Fulda Gap area. The second set of coordinates is the Universal Transverse Mercater (UTM) coordinates. The UTM coordinates provide the user with a vehicle to transfer the grid map data to an actual map of the Fulda Gap area to analyze the correctness of the combat model. The grid map utilizes a scale factor which displays only the area of combat used within the model facilitating a better representation of the grid map. It uses three symbols to display the information upon the map. A tank symbol is used to represent the unit's location during land combat. This symbol is drawn for the initial location of each unit and again when a unit has tranversed more than two-hundred meters from its initial position. When the units has moved more than two-hundred meters, the new location becomes the initial position for further comparisons. The symbol for the primary firing positions of the defensive forces is a solid line in the shape of a crescent. The last symbol represents the alternate firing positions of the defensive forces and is a dashed line in the shape of a crescent. Thus, a defensive force at its initial location will have a tank and a solid line crescent, whereas the aggressor force will have a tank only. Each force location is identified with a numerical value representing the force (i.e. 1, 2, or 3 for the aggressor forces and 4, 5, or 6 for the defensive forces). The grid map presents a still picture view of the land combat phase as it transitions through the combat model.

V. EXECUTIVE PROGRAM

With the development of an interactive graphical support for a small-unit amphibious operation combat model, a method was needed to interface the two programs. Due to the extensive length of the two programs, the author felt that it would be beneficial to maintain two separate programs and to interface them via an executive program. The executive program was developed with simplicity in mind. By typing one word the user is able to engage the executive program and sequentially progress through the model and support program. Detailed information concerning the executive program is presented in Appendices A and C. A brief synopsis of the executive program follows:

1. Compile the small-unit amphibious operation combat model and the interactive support programs.
2. Erase the listings of the two programs.
3. Establish the file definitions required for the two programs.
4. Load and execute the model.
5. Access DISSPLA EXEC which loads and executes the interactive graphical support.
6. Print the battle summary contained in AMPHIB1 LISTING file.
7. Browse the AMPHIB1 LISTING file.
8. Exit when the user is finished.

VI. FUTURE ENHANCEMENTS

The interactive graphical support for a small-unit amphibious operation combat model provides a capability to the user to visually assimulate (i.e. to better comprehend and understand) the model's output data via graphical representation of that data. The support program provides three types of graphical representations in this repect. Although these graphical representations are not an end in themselves, they are a valuable adjunct to the usual approach of giving the user nonresponsive, rigidly fomatted output data even if this be via computer graphics. There still remain things to be done.

A. INTERACTIVE UPGRADE OF THE MODEL

As discussed previously in this thesis, the small-unit amphibious operation combat model was upgraded by changing two of the automatic input data items to interactively being inputted by the user. However, the use of interactive input within the model should not stop at this juncture. There exists within the SEA1 DATA and LAND DATA files other input data variables that are capable of being inputted interactively. By inputting data in this manner, the user does not have to exit the model and then edit the data set to change an input data variable. The designer would have to restructure the model by designing various menus to facilitate the exchange of input between the user and the program. The designer would also have to consider the principle of self-helping by providing checks of the user's input to ensure that the input conforms to the input data requested. By developing this enhancement the user would access a model which would be extremely flexible, simple and friendly.

B. COLOR GRAPHICS

Presently the interactive graphical support utilizes a Tektronic hard copier or a Versatec plotter and the screen of the Tektronic 618 to provide to the user the graphical representation of the model's data. The graphical representation of the model's data could be enchanced by employing a color graphics device as the output device for the support program. The use of color graphics provides the ability for the user to emphasize a particular detail of the data, and regarding the grid map on opportunity to provide a realistic representation of the terrain in the Fulda Gap area of West Germany. By using color graphics the support program is able to present a more appealing and comprehensive representation of the data.

C. CONTOUR MAP

The map of the combat area is only a grid map and does not present the terrain relief within the Fulda Gap area. This does not give the user a realistic or comprehensive picture of the avenues of approach of the aggressor forces in the land combat phase. By incorporating the contour lines of this area, the user is able to relate the avenues of approach to the type of terrain that the units are moving over. Thus, the grid map takes on a new dimension for the user. Also, the user is able to utilize the contours to help determine whether or not the model provides realistic data. Additionally, if the user wishes to input the attack routes, he will get a better feel for these routes and be better able to provide realistic attack routes. The adding of this enhancement to the interactive graphical support would definitely add a new dimension to the grid map. The data associated with the contour lines of the Fulda Gap area can be obtained from TRADOC Research Element Monterey (TREM) which is located aboard the Naval Postgraduate School.

VII. FINAL REMARKS

The goal of this thesis was to take a first step towards developing an interactive graphical support for a small-unit amphibious operation combat model. Having accomplished this goal within this thesis, this interactive graphical support has laid the foundation from which a variety of options can be built. This model with its support program provides a new dimension to combat modeling for the user (not necessarily an advanced modeler) to examine, analyze, restructure, and learn from. Thus, within a combat modeling course, a command, control and communications related course, or a computer graphics course, this model with its support program can be employed as a training aid to illustrate a basic combat model with interactive graphical support. The use of the product of this thesis provides a starting point for branching into other areas of combat modeling utilizing interactive computer graphics.

APPENDIX A

USER'S MANUAL

for the

INTERACTIVE GRAPHICAL SUPPORT

and

A SMALL-UNIT AMPHIBIOUS OPERATION COMBAT MODEL

I. INTRODUCTION

The purpose of this manual is to provide to the user a summary of the interactive graphical support program and the information describing how a user would access and execute both the above program and the small-unit amphibious operation combat model. This manual does not discuss in detail the small-unit amphibious operation combat model, but does discuss those areas which clairify the support program's discussion. For a detailed explanation of the combat model refer to Crites' thesis identified in Reference 1. The interactive graphical support is a FORTRAN program which consists of a main program and seven subprograms. The main program's functions are to input the data generated from the running of the small-unit amphibious operation combat model, to initialize the data for further use within the main program, and to guide the user toward the graphical display of the data. The main program consists of five features which perform the functions listed above. The first feature is the data handling feature which is responsible for inputting the generated data of the combat model into appropriate data structures and variables, for storing and initializing the attrition data base, and for scaling the attrition data if required. The second feature is the interactive feature which interfaces with the user regarding the selection process associated with a variety of menus within the main program. The third, fourth and fifth features comprise the portion of the main program which contains the DISSPLA subroutines for displaying the line graphs, bar charts, and a grid map, respectively. The latter three features depend upon the interactive feature which provides the menu selections of the user determining which feature is displayed upon a graphics device.

II. INTERACTIVE OPTIONS OF THE MODEL

The small-unit amphibious opertion combat model possesses certain options which were developed prior to this thesis. These options were developed by Jim Crites in his thesis and dealt with stochastic versus deterministic attrition, variant attack routes and alternate defensive positions. These options are selected by manually replacing the default data with the desired data within the SEA1 DATA and LAND DATA files. With the development of the interactive graphical support, an upgrade of the option capability of the model was undertaken by incorporating an interactive capability for inputting two of the many options available within the model.

A. BATTLE SUMMARY

The battle summary is the portion of the output report which provides information concerning the forces involved within both combat phases of the small-unit amphibious operation combat model. This information depicts the units in combat, their coordinate locations, the attrition percentage of each unit, and the identification of which units engaged each other. The information can be displayed for each time step or at the termination of battle for each combat phase. The user makes the determination of the battle summary that he wishes to receive by selecting the appropriate menu option relating to the detail of information desired. The following menu is displayed to the user.

```
            BATTLE SUMMARY MENU

1.  BATTLE SUMMARY FOR EACH TIME STEP IN
    BOTH COMBAT PHASES
2.  BATTLE SUMMARY FOR FINAL TIME STEP IN
    BOTH COMBAT PHASES
```

Thus, if the user selects option number one, the battle summary for each time step in both combat phases is incorporated into the report contained in the AMPHIB1 LISTING file. If the user selects option number two, the battle summary for the final time step (i.e. when the battle terminates) is incorporated into the report of the above file. With this option the user is able to select the level of detail over which he wishes to analyze the data.

B. TIME STEP

The time step variable determine the iteration interval that the model is executed over. The previous value of the time step was set at ten seconds. This does not provide the flexibility to the user to evaluate the model over varied time steps. By transitioning this variable to an interactivly inputted one, the user now has the flexibility to determine the time step within the combat model. Since there are two combat phases within the model, the time step selection process extends over both combat phases. The first display of the information concerning the time step is more verbose than the second within the land combat phase. The reason for this is to present additional information pertinent to the selection of the time step. Within the ship-to-shore combat phase, the following information is presented to the user regarding the time step.

```
        SELECTION OF THE TIME STEP FOR THE
              SHIP-TO-SHORE PHASE

   THE USER IS PROVIDED THE OPPORTUNITY TO SELECT THE
   TIME STEP THAT HE WISHES THE MODEL TO UTILIZE FOR
   DETERMINING THE ATTRITION OF FORCES.  THIS INTERVAL
   WILL ALSO BE DISPLAYED AS THE X-AXIS ON THE LINE
   GRAPH WHICH IS PRODUCED BY THE GRAPHICAL SUPPORT
   PROGRAM.
```

```
THE TIME STEP IS IN SECONDS AND ENTERED IN THE
FOLLOWING MANNER:

     1.  DECIDE UPON THE TIME STEP.
     2.  ENTER THE TIME STEP (E.G. 30 SECONDS --
         30.), THEN PRESS THE ENTER KEY.
```

To continue the selection process, the following is displayed within the land combat phase:

```
        SELECTION OF THE TIME STEP FOR THE
                LAND COMBAT PHASE

    DO YOU WISH TO KEEP THE SAME TIME STEP FOR THE
    LAND COMBAT PHASE THAT YOU USED FOR THE SHIP-
    TO-SHORE COMBAT PHASE?

                PRESS 'Y' FOR YES
                PRESS 'N' FOR NO
```

If the user answers no to the above option, the program will present the following display to the user:

```
    PLEASE ENTER YOUR DESIRED TIME STEP FOR THE LAND
    COMBAT PHASE (E.G. 10 SECONDS, ENTER '10.'),
    THEN PRESS THE ENTER KEY.
```

With this option the user is now able to determine the time step during which he wishes the model to perform the iterations for either combat phase of the model.

III. INTERACTIVE OPTIONS OF THE GRAPHICAL SUPPORT PROGRAM

As discussed in the introduction to this user's manual, the interactive graphical support program is divided into a main program and seven subprograms. Within the main program there are basically five features which handle the various functions of the main program. This section will focus on the interactive feature which is the first feature that the user interfaces with the remaining features being discussed later on in this manual. The interactive feature of the main program is built along the lines of a hierarchical structure containing six levels. The user may only exit the main program at levels one and two, whereas the remaining levels return the user to the succeeding level. Level six returns the user to the level five menu which called the graphics display.

A. LEVEL ONE

Level one presents the title page for the main program and flows into the program selection menu. This menu determines whether the introduction, beginning of the selection process, or exiting the program option is processed. The program selection menu is displayed in the following manner:

```
        PROGRAM SELECTION MENU

    1.  READ THE INTRODUCTION
    2.  BEGIN THE GRAPHICS PROGRAM
    3.  EXIT THE PROGRAM
```

B. LEVEL TWO

Level two contains the introduction and the main menu selection. The introduction is displayed if the user selects option one from the program selection menu. It consists of three pages of introductory material regarding the interactive graphical support program. To read each page of the introduction, the user has to only press the enter key on the IBM 3277 keyboard. On the third press of the enter key the program automatically displays the main menu of the program. The main menu is also reached if the user selected option two from the program selection menu. The main menu provides the user the option to enter the ship-to-shore combat phase graphics, the land combat phase graphics, or exit the program and is displayed as follows:

```
                    MAIN MENU

       1.  SHIP-TO-SHORE COMBAT PHASE GRAPHICS
       2.  LAND COMBAT PHASE GRAPHICS
       3.  EXIT THE PROGRAM
```

Upon a selection from the main menu, the program enters level three.

C. LEVEL THREE

Level three consists of two menus. The menus are the ship-to-shore and the land combat menus. Each menu will be discussed separately.

1. Ship-to-Shore Menu

The ship-to-shore menu provides the user three options to select from. The fist option deals with the attrition analysis per time step which directs the user to another menu to determine which group of forces that he desires to analyze. The second option deals with the final

attrition of the forces in combat. This option leads to the final attrition data menu where the user determines which group of forces to display. The first and second options branch the user to level four of the main program. The third option returns the user to the main menu. The menu for this section follows:

SHIP-TO-SHORE MENU

1. ANALYSIS OF FORCES BY TIME STEP
2. ANALYSIS OF FORCES BY FINAL ATTRITION DATA
3. RETURN TO MAIN MENU

The option selected by the user is placed into the first element of the ISTSA array which contains the menu selections for the ship-to-shore combat phase. This array is a one dimensional array with four elements which are tested later on to determine which graphics display is presented to the user. In subsequent levels the remaining elements of this array are initialized depending upon the branch that the user selects.

2. Land Combat Menu

The land combat menu has four options to select from. The first and second options pertain to the same subject matter as stated in the previous section except that they relate to the land combat phase. The third option deals wtih the grid map. When the user selects this option, the main program branches to the grid map feature, process the DISSPLA software, and displays the grid map upon a graphics device. The grid map is discussed in detail in a later section of this appendix. The final option returns the user to the main menu. The land combat menu follows on the next page.

LAND COMBAT MENU

1. ANALYSIS OF FORCES BY TIME STEP
2. ANALYSIS OF FORCES BY FINAL ATTRITION DATA
3. GRID MAP WITH ALTERNATE POSITIONS/ LOCATION OF UNITS
4. RETURN TO MAIN MENU

Here the option selected by the user is placed into the first element of the ILCA array consisting of four elements which are checked later on for the appropriate branching instruction. The remaining elements of this array are filled in later levels within this program. This array contains the menu selections for the land combat phase.

D. LEVEL FOUR

Level four consists of two different types of menus. One type deals with the time step and the other type deals with the final attrition data. Each type will be discussed separately so as not to confuse the reader.

1. Time Step Menu

The time step menu is reached by the selection of option one from the ship-to-shore menu or the land combat menu. This menu provides the user the opportunity to determine which group of forces that he wishes to select for analysis. The group of forces are the aggressor or defensive force. With the selection of one of these two forces, the program branches to level five of the main program and the appropriate menu displaying the forces avaiable for analysis. The numerical value of the option selected is placed into the second element of the ISTSA or ILCA array depending upon the previous menu displayed. The time step menu follows on the next page.

TIME STEP MENU

1. ANALYSIS OF AGGRESSOR FORCES
2. ANALYSIS OF DEFENSIVE FORCES
3. RETURN TO SHIP-TO-SHORE OR LAND COMBAT MENU

2. Final Attrition Data Menu

The final attrition data menu is the first menu that upon selection of an option culminates with a graphical display upon a graphics device. This menu provides the user the opportunity to select between the aggressor or defensive forces in combat which displays the selected force upon a graphics device. The same menu is displayed to both of the combat phases if the user selected option two from the ship-to-shore or the land combat menu. The numerical value of the option selected is placed within the fourth element of the ISTSA or ILCA array. Depending upon the option selected, the program branches to the appropriate portion of the bar chart feature and displays the bar chart of the forces selected. This is the final attrition data menu that is displayed for both combat phases.

FINAL ATTRITION DATA MENU

1. AGGRESSOR FORCES
2. DEFENSIVE FORCES
3. RETURN TO SHIP-TO-SHORE OR LAND COMBAT MENU

E. LEVEL FIVE

Level five consists of two distinct menus for both the ship-to-shore and land combat phases. The first menu deals with the aggressor forces of both combat phase. Each combat phase has a separate menu due to different units employed in each combat phase and if both combat phases were combined, the number of options in this display could be as many as

twelve which is excessive for a display. The numerical value of the option selected from these menus is placed into the third element of the two arrays: ISTSA and ILCA. Here is the aggressor force menu for the ship-to-shore combat phase.

```
        AGGRESSOR FORCES
   SHIP-TO-SHORE COMBAT PHASE

        1.  WAVE ONE
        2.  WAVE TWO
        3.  WAVE THREE
        4.  WAVE FOUR
        5.  WAVE FIVE
        6.  ALL AGGRESSORS
        7.  RETURN TO TIME
            STEP MENU
```

Option number seven provides the capability to display all the aggressor forces on one line graph. Here is the aggressor force menu for the land combat phase.

```
      AGGRESSOR FORCES
      LAND COMBAT PHASE

        1.  UNIT ONE
        2.  UNIT TWO
        3.  UNIT THREE
        4.  ALL AGGRESSORS
        5.  RETURN TO TIME
            STEP MENU
```

With the selection of option four, the attrition per time step for all aggressor forces is displayed on one line graph.

The second menu deals with the defensive forces of both combat phases. The contents for each combat phase is different because of the difference between the units involved in the two combat phases. The numerical value of the option selected is also placed into the third element of the ISTSA and ILCA arrays. This element can be used for this selection, as well as the previous selection, because the user can only select one of the four menus in level five due to

the manner in which the structure of the program was established. The defensive force menu for the ship-to-shore combat phase is displayed in the following manner to the user.

```
          DEFENSIVE FORCES
    SHIP-TO-SHORE COMBAT PHASE

          1.   TANK
          2.   ATGM
          3.   ALL DEFENDERS
          4.   RETURN TO TIME
               STEP MENU
```

The defensive force menu for the land combat phase is displayed in the following manner to the user.

```
        DEFENSIVE FORCES
        LAND COMBAT PHASE

          1.   UNIT FOUR
          2.   UNIT FIVE
          3.   UNIT SIX
          4.   ALL DEFENDERS
          5.   RETURN TO TIME
               STEP MENU
```

The selection of options three and four in the above two menus causes the line graph to display all of the defenders of that menu. Once the selection is made from any of the four menus on this level, the program will branch to the appropriate section of the line graph feature and display the force or forces selected.

IV. DISSPLA SOFTWARE

DISSPLA stands for Display Integrated Software System and Plotting Language which is a proprietary software product of Integrated Software System Corporation (ISSCO). DISSPLA is written in FORTRAN and is a library of subroutines that facilitate data plotting. The software is device independent in that a user can debug his plots on a CRT terminal and submit the finished program to a flatbed or drum plotter. It is computer independent because its subroutines are written in a subset of ANSI FORTRAN which is common to most medium- and large-scale computers. DISSPLA provides many levels of sophistication to the user. The user can develop a quick, simple plot or advance to more complex and detailed plots with just a few simple calls. DISSPLA possesses a helpful design in that it provides error messages which are self-explanatory sentences in English. It also assists the user by printing out-of-bounds values and diagnostic plot summaries. To utilize DISSPLA effectively all that is needed by the user is a basic knowledge of FORTRAN and access to the user's manual or pocket guide.

The DISSPLA software used within the interactive graphical support program consists of a number of subroutines which produces three features: line graph, bar chart, and grid map. Each feature is comprised of different subroutines to fulfill its function. Prior to the main program of the interactive graphical support calling one of the three features for displaying their respective product, a group of DISSPLA subroutines is called to select the buffer size for DISSPLA, to establish the graphic devices for output, to select plot scale factor and to set curve thickness. The following subroutines are the ones called to perform the above functions and will be listed without their parameters if applicable.

SUBROUTINE	DESCRIPTION
CALL LRGBUF	SELECT LARGE BUFFER
CALL TEK618	SELECT GRAPHIC DEVICE
CALL BLOWUP	SELECT PLOT SCALE FACTOR
CALL THKCRV	EMPHASIS A LINE BY THICKENING

Once the main program has executed the above subroutines, one of the three features is processed depending upon the menu selections of the user. The remaining discussion about DISSPLA focuses on the FORTRAN subroutines utilized by the three features.

A. LINE GRAPH FEATURE

The line graph feature of the main program consists of FORTRAN subroutines which when processed displays a line graph dealing with attrition of forces within the combat model. This feature primary consists of two functions. The first function being the initialization of the plot and the second is the branching function. Within the initialization of the plot, a variety of subroutines are called to setup the line graph prior to branching. These subroutines establish the rotation of the plot, page size, physical origin, plot area size, and axis labels. The following subroutines are associated with the line graph feature and are listed without their parameters if applicable.

SUBROUTINE	DESCRIPTION
CALL HWROT	SELECTS PLOT ROTATION; COMIC OR MOVIE MODE
CALL PAGE	SETTING PAGE SIZE BORDER
CALL PHYSOR	DEFINE PHYSICAL ORIGIN
CALL AREA2D	SPECIFY SIZE OF SUBPLOT AREA
CALL XNAME	LABEL X-AXIS

SUBROUTINE	DESCRIPTION
CALL YNAME	LABEL Y-AXIS
CALL XINTAX	SPECIFY INTEGER LABELS ON X-AXIS
CALL YINTAX	SPECIFY INTEGER LABELS ON Y-AXIS
CALL XTICKS	DRAW ADDITIONAL TICK MARKS ON X-AXIS
CALL YAXANG	SET ANGLE OF Y-AXIS

When the main program has advanced through the above subroutines, the program then branches to the correct line graph selected by the user. There are four possible branches. They are aggressor or defensive unit for ship-to-shore combat phase, or aggressor or defensive unit for land combat phase. Each branch basically utilizes the same DISSPLA subroutines, but with different parameters for each branch. Once inside a branch, the main program selects the appropriate unit or units to display for the user. The following are the DISSPLA subroutines within these four branches.

SUBROUTINE	DESCRIPTION
CALL GRAF	PRIMARY GRAPH SETUP
CALL HEADIN	DEFINE GRAPH HEADING
CALL DASH	ACTIVATES DASHED LINE CONNECTION
CALL MARKER	SELECT SPECIFIC CURVE MARKER SYMBOL
CALL CURVE	DRAWS A CURVE THROUGH A SET OF DATA COORDINATES
CALL YGRAXS	SECONDARY Y-AXIS WITH UNITS
CALL RESET	RESET A PARAMETER/SETTING OPTION TO ITS DEFAULT VALUE
CALL ENDPL	TERMINATES PLOTTING ON CURRENT PAGE
CALL LEGLIN	CAUSES CURVE TO STORE THE TYPE OF LINE DRAWN
CALL DOT	ACTIVATES DOTTED LINE CONNECTION

SUBROUTINE	DESCRIPTION
CALL CHNDOT	ACTIVATES CHAIN DOTTED LINE CONNECTION
CALL CHNDSH	ACTIVATES CHAIN DASHED LINE CONNECTION
MAXLIN=LINEST	INITIALIZE AN ARRAY TO RECEIVE PACKED LINES
CALL LINES	PACK A LINE OF TEXT
CALL LEGEND	WRITES OUT THE LEGEND

B. BAR CHART FREATURE

The bar chart feature consists of two functional areas. The first area initializes the bar chart while the second area branches to the user selected bar chart. The first area performs the same functons as discussed in the previous section under the line graph relating to the initialization function. This feature does employ some DISSPLA subroutines which are different then the ones in the line graph. The subroutines are shown below.

SUBROUTINE	DESCRIPTION
CALL XAXEND	SUPPRESSES LABELS ON X-AXIS
CALL BARWID	INDICATES BAR WIDTH

The second functional area is branching. Here the program only branches to the ship-to-shore or land combat phase branch. The following DISSPLA subroutines are utilized in the two branches.

SUBROUTINE	DESCRIPTION
CALL XLABGR	X-AXIS USER LABELLED
CALL BLEAR	AUTOMATICALLY BLANKS BAR CHART
CALL BARDOC	CAUSES DATA TO BE WRITTEN IN OR AROUND BARS

SUBROUTINE	DESCRIPTION
CALL VBARS	PRESENTS DATA IN VERTICAL BAR CHART FORM
CALL GRID	DRAWS APPROPRIATE GRID FOR THE CURRENT GRID SYSTEM

There are additional DISSPLA subroutines utilized in this functional area, but they have been covered in the line graph feature and are not presented again.

C. GRID MAP FEATURE

The grid map feature does not consist of any braching requirement, thus the main program when it enters this feature sequentially executes each line of FORTRAN code. There are a number of DISSPLA subroutines utilized in this feature which have been discussed in the line graph and bar chart features' section. Therefore, these DISSPLA subroutines are only listed for the user who can refer back to the two previous sections for a description of them if needed. They are:

DISSPLA SUBROUTINES

CALL HWROT	CALL XINTAX	CALL YINTAX
CALL AREA2D	CALL YAXANG	CALL XNAME
CALL YNAME	CALL XTICKS	CALL HEADIN
CALL GRAF	CALL MARKER	CALL CURVE
CALL LEGLIN	MAXLIN=LINEST	CALL LINES
CALL LEGND	CALL YGRAXS	CALL GRID
CALL RESET	CALL ENDPL	

The following is a list of the new DISSPLA subroutines which are utilized within the grid map feature.

NEW DISSPLA SUBROUTINES

SUBROUTINE	DESCRIPTION
CALL YTICKS	TICK MARKS ON Y-AXIS
CALL HEIGHT	SET REFERENCE CHARACTER HEIGHT IN INCHES
CALL RLINT	PLOT AN INTEGER NUMBER
CALL BLREC	CREAT A NON-TILTED RECTANGULAR BLANKED-OUT AREA
CALL MESSAG	WRITE A SINGLE STRING OF TEXT
CALL SCLPIC	SCALES CURVE MARKER SYMBOLS UP OR DOWN
CALL XGRAXS	SECONDARY X-AXIS WITH UNITS/DIVISION

V. ACCESSING AND EXECUTING THE MODEL AND GRAPHICAL SUPPORT PORGRAM

The user who wishes to access and execute the small-unit amphibious operation combat model and the interactive graphical support programs must first contact Professor James G. Taylor of the Operations Research Department. The user will obtain from Professor Taylor the user identification (ID) number and password for the disk space containing the above mentioned programs.

A. ACCESSING THE MODEL AND SUPPORT PROGRAM

The following sequence is followed by the user after obtaining the user ID number and password:

1. Log on to your own disk space.
2. Enter into the CMS mode of operation.
3. Ensure that storage is 1M; if not, type DEF STOR 1M.
4. Execute the following commands:

```
LINK TO (USER ID ) 191 AS 192 RR
PASSWORD
ACCESS 192 B/A
COPYFILE WAR1 FORTRAN B = = A
COPYFILE GRAFIT FORTRAN B = = A
COPYFILE SEA1 DATA B = = A
COPYFILE LAND FORTRAN B = = A
COPYFILE BSEA1 FORTRAN B = = A
COPYFILE BLAND FORTRAN B = = A
COPYFILE WAR1 EXEC B = = A
RELEASE 192 (DET
```

NOTE: USER ID refers to the one the user is provided by Professor Taylor

A copy of the following files is what the user receives on his disk space:

FILES

1. WAR1 - Small-Unit Amphibious Opration Combat Model program.
2. GRAFIT - Interactive Graphical Support program.
3. SEA1 - Data set for the ship-to-shore combat phase (Appendix B).

4. LAND - Data set for the land combat phase (Appendix B)
5. BSEA1 - Blank data set for the ship-to-shore combat phase (Appendix B).
6. BLAND - Blank data set for the land combat phase (Appendix B).
7. WAR1 - Executive program (Appendix C).

Due to the coded length of the computer programs of the small-unit amphitious operation combat model and interactive graphical support, these two computer programs were not reproduced for inclusion within this thesis. A user may obtain a printed copy of these programs once he has the programs residing on his disk space.

B. EXECUTING THE MODEL AND SUPPORT PROGRAMS

There are basically three ways to execute the model in conjunction with the support program. First, the user can type the executive program name, WAR1, utilizing the data set provided by SEA1 DATA and LAND DATA files. Second, if the user wishes to invoke one of the options avaiable within the data set or alter a specific element of them, the user needs to XEDIT the SEA1 and LAND data files replacing the old with the new input data value. Third, if he wishes to replace the entire data set, he would then utilize the BSEA1 and BLAND data files to construct the new data set. Before the user can use the new data set from the second or third way above, he must first XEDIT the WAR1 EXEC file replacing SEA1 and LAND with BSEA1 and BLAND within the file definition part of the executive program. After completing the XEDIT function, the user types WAR1 to begin the execution process.

C. CHECKLIST

When executing the interactive graphical support program, there is a requirement for employing up to three different types of computer hardware. The checklist listed on the following page provides the information for utilizing an IBM 3277 terminal and keyboard, Tektronix 618, and Tektronix 4631.

CHECKLIST

1. TURN ON THE IBM TERMINAL 3277 BY PULLING OUT THE "ON-PUSH" SWITCH LOCATED ON THE LOWER LEFT HAND SIDE OF THE SCREEN.

2. TURN ON THE TEKTRONIX 618 BY PRESSING THE "OFF ON" SWITCH TO THE ON POSITION.

3. ON THE TEKTRONIX 618 ENSURE THAT THE FOLLOWING SWITCHES ARE SET ACCORDINGLY:

   A. WRITE THRU INTENSITY SWITCH SHOULD BE SET AT ONE O'CLOCK.

   B. HARD COPY INTENSITY SWITCH SHOULD BE SET BETWEEN ONE TO THREE O'CLOCK.

4. TURN ON THE TEKTRONIX 4631 - HARD COPY PRINTER - BY PRESSING THE POWER SWITCH TO THE ON POSITION AND SETTING THE "LIGHT DARK" SWITCH TO THREE O'CLOCK.

5. THE TEKTRONIX 4631 TAKES APPROXIMATELY FIVE MINUTES TO WARM UP BEFORE A HARD COPY CAN BE MADE.

6. LOG ON TO THE 3277:

   A. PRESS THE "CLEAR" KEY THAT IS LOCATED ON THE UPPER LEFT HAND CORNER OF THE KEYBOARD; THIS WILL ERASE THE NPS LOGO.

   B. ENTER YOUR LOG IN NUMBER AND PASSWORD.

   C. TO CLEAR THE SCREEN WHEN "MORE...." IS DISPLAYED PRESS THE "CLEAR" KEY.

7. RUN THE PROGRAM:

   A. EXECUTIVE PROGRAM'S FUNCTIONS:

      (1) COMPILE "WAR1" AND "GRAFIT" FORTRAN PROGRAMS.

      (2) FILE DEFINITIONS OF THE FILES FOR THE TWO PROGRAMS.

      (3) LOAD AND START "WAR1" FORTRAN PROGRAM.

      (4) ACCESS DISSPLA EXEC TO LOAD AND START "GRAFIT" PROGRAM.

      (5) PRINT "AMPHIB1 LISTING".

      (6) EXIT THIS EXECUTIVE PROGRAM.

   B. TYPE "WAR1" TO BEGIN THE EXECUTION OF THE "WAR1 EXEC".

VI. EXPECTED OUTPUT

The user of the small-unit amphibious operation combat model and the interactive graphical support program can expect to receive or view three types of output. Two of the types deal with alphanumeric characters and one type deals with graphical output. Each type is discussed under the program which gererates that type of output.

A. SMALL-UNIT AMPHIBIOUS OPERAION COMBAT MODEL OUTPUT

The small-unit amphibious operation combat model produces an alphanumeric character type of output. There are two forms of the alphanumeric character type produced by this model. These two forms are contained in the model's output report. The first form which comprises the first portion of the model's output report for each combat phase is the initial information providing the user feedback on the user supplied input data. The second form which comprises the remainder of the model's output report is the battle summary providing attrition data and other force information at speified time step or steps. Appendix D depicts an example of the model's output report.

B. INTERACTIVE GRAPHICAL SUPPORT OUTPUT

The interactive graphical support produces the third type of output: graphical. This type of output requires a graphics device for viewing. The types of devices available for viewing the graphics output are Tektronix hard copy printer and Versatec plotter located in Ingersoll Hall, room 149 or the Versatec plotter located within the computer center in Ingersoll. There are three types of graphical output generated by the interactive graphical support

program. The first type is a line graph which displays the attrition of force(s) per time step. The second type is the bar chart which displays the attrition of forces (i.e. aggressor or defensive forces) at the termination of the battle. The final type is the grid map which depicts the Fulda Gap area utilizing a grid system without contour lines. This map displays the initial location of forces, avenues of approach of the aggressors, and primary and alternate firing positions of the defensive forces. Each unit is depicted by a tank symbol, and the primary and alternate firing positions by appropriate crescent drawings. An example of each type of graphical output is illustrated in Appendix D.

VII. PROGRAM STRUCTURE

Both the small-unit amphibious operation combat model and the interactive graphical support are computerized programs written in FORTRAN. Both programs consist of a main program and several subprograms. The subsequent discussion regarding the model's program focuses on the addition of three subprograms, whereas the discussion on the support program focuses on the main program and its various subprograms.

A. RESTRUCTURED MODEL'S PROGRAM

The restructuring of the model's program occurred in the subprogram area with the addition of three subroutines. The function of each subroutine is discussed within the introductory section of the graphics portion of the model's program and of each subroutine. A discussion of each subroutine is now presented.

1. Subroutine ANSWER

Subroutine ANSWER provides the user with a friendly, interactive interface with the program. This subroutine accepts the typed input of the user and determines whether it is a real or integer number, or an alphabetical character. If the user only presses the ENTER key when a desired input is requested, this subroutine waits for the user to enter the correct input which provids the program with a self-helping feature.

2. Subroutine CLEAR

Subroutine CLEAR provides a means for the user to clear the screen whenever the appropriate prompt is displayed. The prompt to the user is shown below.

PRESS THE ENTER KEY TO CONTINUE

The subroutine accepts the press of the enter key and calls a FORTRAN CMS subroutine built into the CMS library which clears the screen. The call to the subroutine is as follows: CALL FFTCMS ('CLRSCRN '). Upon clearing of the screen, the subroutine returns control to the program where it was involked.

3. BLOCK DATA

BLOCK DATA is a subprogram used to initialize variables which are part of a labeled (i.e. named) common block. This subprogram has to be the last subprogram within a FORTRAN program to work properly. By labeled is meant, a group of variables is referred to by a single name and placed into a common location for accessing and storage. Here is an example of a common block.

```
COMMON  /PASS1/KBORARD, DECIML, INTEGR, YES
```

In this example the word PASS1 is the labeled name for the common block.

B. INTERACTIVE GRAPHICAL SUPPORT PROGRAM

The interactive graphical support program consists of a main program and seven subprograms. Three of the seven subprograms have been discussed in the previous section which are subroutine ANSWER, subroutine CLEAR, and subprogram BLOCK DATA. The functions of these subprograms are the same as discussed above. Therefore, these three subprograms are not discussed in this section. This section discusses the main program and the remaining subprograms that comprise the support program.

1. Main Program

The main program is the backbone of the interactive graphical support program. It handles initializing and declaring of arrays and variables, inputting of data from the small-unit amphibious operation combat model, displaying of the introduction to the screen, and branching to the line graph, bar chart, or grid map feature. The main program interfaces with the user by displaying certain statements quering the user for responses which are the branching instructions for the main program to react upon. The main program takes these braching instructions, branches to the appropriate graphics feature, and displays the desired feature on the graphics device. This process continues until the user decides to exit the main program. Prior to and during the interfacing with the user, the main program utilizes subprograms to facilitate in performing its functions. There are three subprograms which are identical to the three previouly discussed in the above section and will not be discussed again in this section. They are subroutine ANSWER, subroutine CLEAR and subprogram BLOCK DATA. The remaining subprograms utilized by the main program will be discussed in alhpabetical order.

2. Subroutine INITAL

Subroutine INITAL determines from amoung the arrays filled by the subroutine INPUT which amount of the attrition data is to be kept. Due to the limited size of the display area within the line graph, not all of the attrition data can be displayed. Thus, this subroutine determines the proportion of attrition data that is to be used in the display. The criteria of the selection process relating to the attrition data follows:

> If the number of time steps is greater than 55, accept every fourth data point.
>
> If the number of time steps is greater than 25 and less than or equal to 55, accept every second data point.
>
> If the number of time steps is less than or equal to 25, accept every data point.

This selection process is also associated with determining the x-axis label (i.e. time step) on the line graph, so that the data and the time step match each other.

3. Subroutine INPUT

Subroutine INPUT accesses the output data of the small-unit amphibious operation combat model from the user's disk space. The input data are placed in appropriate data structures for further processing and analysis within the main program.

4. Subroutine PICTUR

Subroutine PICTUR is a DISSPLA subroutine which draws a user defined picture. This subroutine produces three types of symbols utilized in the grid map display. The first symbol is the unit symbol which is a tank. This

symbol is placed on the initial location of each unit and subsequent locations if movement is greater than two-hundred meters from the initial location. If the unit does move further than two-hundred meters, the new location becomes the initial location for further comparisons. The second symbol is the primary firing position symbol which is a crescent shaped solid line. The final symbol is the alternate firing position symbol which is a crescent shaped dashed line.

5. Function VALMAX

Function VALMAX is a real function whose input parameter is an array and output value is the maximum value within the inputted array.

VIII. DEFINITIONS OF VARIABLES

The definitions of variables are discussed according to which program the variable is utilized in. This section consists of two sections with the first section dealing with the variables added to the small-unit amphibious operation combat model for this thesis, and the second section dealing with the variables within the interactive graphical support program.

A. SMALL-UNIT AMPHIBIOUS OPERATION COMBAT MODEL

The below listed variables for the small-unit amphibious operation combat model does not represent the entire list of variables. The variables listed are the ones added to the combat model for this thesis. For a detail listing of the remaining variables of the combat model refer to Appendix A, Section VII of Crites' thesis.

COMBAT MODEL VARIABLES

NAME	DEFINITION
DECIML	REAL VALUE RETURNED BY SUBROUTINE ANSWER
GFSUR	ARRAY WHICH CONTAINS VALUES OF ATTRITION FOR EACH FORCE AT THE FINAL TIME STEP DURING LAND COMBAT PHASE
GNPTS	REPRESENTS THE VALUE OF THE TOTAL NUMBER OF LAND TIME STEPS THAT THE MODEL HAS PROCESSED THROUGH
GTSUR	ARRAY WHICH CONTAINS THE VALUE OF THE ATTRITION OF EACH FORCE PER TIME STEP DURING LAND COMBAT PHASE
IBLCT	INTEGER VALUE OF "BEGIN LAND COMBAT TIME"
IELCT	INTEGER VALUE OF "END LAND COMBAT TIME"
IESST	INTEGER VALUE OF "END SHIP-TO-SHORE TIME"
INTEGR	INTEGER VALUE RETURNED BY SUBROUTINE ANSWER

COMBAT MODEL VARIABLES

NAME	DEFINITION
IPRINT	INTEGER VALUE WHICH REPRESENTS THE SELECTION OF THE METHOD THAT THE OUTPUT IS WRITTEN TO THE AMPHIB1 LISTING ON A1 DISK
KBOARD	REPRESENSTS FILE DEFINITION OF "07" FOR KEYBOARD
SFSUR	ARRAY WHICH CONTAINS THE VALUE OF ATTRITION FOR EACH FORCE AT THE FINAL TIME STEP DURING SHIP-TO-SHORE COMBAT PHASE
SLVA	ARRAY WHICH CONTAINS BEGINNING STRENGTHS OF THE LVA'S IN SHIP-TO-SHORE COMBAT PHASE
SNPTS	REPRESENTS THE VALUE OF THE TOTAL NUMBER OF SHIP-TO-SHORE TIME STEPS THAT THE MODEL HAS PROCESSED THROUGH
STATM	ARRAY WHICH CONTAINS BEGINNING STRENGTHS OF THE TANKS AND ATGM'S IN SHIP-TO-SHORE COMBAT PHASE
STSUR	ARRAY WHICH CONTAINS THE VALUE OF THE ATTRITION PER EACH FORCE PER TIME STEP FOR SHIP-TO-SHORE COMBAT PHASE
SUNIT	ARRAY WHICH CONTAINS BEGINNING STRENGTHS OF ALL UNITS WITHIN LAND COMBAT PHASE -- 1 TO 3 => AGGRESSORS; 4 TO 6 => DEFENDERS
TSIG	TIME STEP FOR LAND COMBAT PHASE
TSIS	TIME STEP FOR SHIP-TO-SHORE PHASE
XCK	FLAG USED WITHIN SUBROUTINE GROUND
XCORD	ARRAY WHICH CONTAINS X COORDINATES OF UNITS WITHIN LAND COMBAT PHASE
YCORD	ARRAY WHICH CONTAINS Y COORDINATES OF UNITS WITHIN LAND COMBAT PHASE
YES	LOGICAL VALUE RETURNED BY SUBROUTINE ANSWER

B. INTERACTIVE GRAPHICAL SUPPORT PROGRAM

The variables which are common to the interactive graphical support program are listed first. The remaining variables within the program are listed under their respective subprogram.

COMMON VARIABLES

NAME	DEFINITION
DECIML	REAL VALUE RETURNED BY SUBROUTINE ANSWER
ATGM	ARRAY WHICH CONTAINS PERCENTAGES OF INITIAL UNITS REMANINING OF ATGM UNIT
ATGMA	ARRAY WHICH CONTAINS PERCENTAGES OF INITIAL UNITS REMANINING OF ATGM UNIT; COPY OF PREVIOUS ARRAY
GATM	TIME LAND COMBAT PHASE BEGINS
GASUR	ARRAY WHICH CONTAINS VALUES OF ATTRITION FOR AGGRESSOR FORCES AT FINAL TIME STEP DURING LAND COMBAT PHASE
GDSUR	ARRAY WHICH CONTAINS VALUES OF ATTRITION FOR DEFENSIVE FORCES AT FINAL TIME STEP DURING LAND COMBAT PHASE
GNPTS	REPRESENTS THE VALUE OF THE TOTAL NUMBER OF LAND TIME STEPS THAT THE MODEL HAS PROCESSED THROUGH
GTSX	ARRAY WHICH CONTAINS X-AXIS VALUES OF TIME STEPS IN LAND COMBAT PHASE
IBLCT	INTEGER VALUE OF "BEGIN LAND COMBAT TIME"
IELCT	INTEGER VALUE OF "END LAND COMBAT TIME"
IESST	INTEGER VALUE OF "END SHIP-TO-SHORE TIME"
ILCA	ARRAY WHICH CONTAINS MENU SELECTIONS FOR LAND COMBAT PHASE
INTEGR	INTEGER VALUE RETURNED BY SUBROUTINE ANSWER
ISTSA	ARRAY WHICH CONTAINS MENU SELECTIONS FOR SHIP-TO-SHORE COMBAT PHASE
K	REPRESENTS THE SCALE FACTOR OF THE ATTRITION IN THE LINE GRAPH

COMMON VARIABLES

NAME	DEFINITION
KBOARD	REPRESENTS FILE DEFINITION OF "05" FOR KEYBOARD
NPTG	INTEGER VALUE OF GNPTS
NPTS	INTEGER VALUE OF SNPTS
SASUR	ARRAY WHICH CONTAINS VALUES OF ATTRITION FOR AGGRESSOR FORCES AT FINAL TIME STEP DURING SHIP-TO-SHORE COMBAT PHASE
SDSUR	ARRAY WHICH CONTAINS VALUES OF ATTRITION FOR DEFENSIVE FORCES AT FINAL TIME STEP DURING SHIP-TO-SHORE COMBAT PHASE
SNPTS	REPRESENTS THE VALUE OF THE TOTAL NUMBER OF SHIP-TO-SHORE TIME STEPS THAT THE MODEL HAS PROCESSED THROUGH
STSX	ARRAY WHICH CONTAINS X-AXIS VALUES OF TIME STEPS IN SHIP-TO-SHORE PHASE
TANK	ARRAY WHICH CONTAINS PERCENTAGES OF INITIAL UNITS REMAINING OF THE TANK UNIT
TANKA	ARRAY WHICH CONTAINS PERCENTAGES OF INITIAL UNITS REMAINING OF THE TANK UNIT; COPY OF PREVIOUS ARRAY
TSIG	TIME STEP FOR LAND COMBAT PHASE
TSIS	TIME STEP FOR SHIP-TO-SHORE PHASE
UNIT_	ARRAY WHICH CONTAINS PERCENTAGES OF INITIAL UNITS REMAINING OF AGGRESSOR'S UNITS; THE ARRAYS ARE NUMBERED FROM 1 TO 3
UNIT_A	ARRAY WHICH CONTAINS PERCENTAGES OF INITIAL UNITS REMAINING OF AGGRESSOR'S UNITS; THE ARRAYS ARE NUMBERED FROM 1 TO 3; COPY OF PREVIOUS ARRAY
UNIT_	ARRAY WHICH CONTAINS PERCENTAGES OF INITIAL UNITS REMAINING OF DEFENDER'S UNITS; THE ARRAYS ARE NUMBERED FROM 4 TO 6
UNIT_A	ARRAY WHICH CONTAINS PERCENTAGES OF INITIAL UNITS REMAINING OF DEFENDER'S UNITS; THE ARRAYS ARE NUMBERED FROM 4 TO 6; COPY OF PREVIOUS ARRAY
WAVE_	ARRAY WHICH CONTAINS PERCENTAGES OF INITIAL UNITS REMAINING OF AGGRESSOR'S WAVES; THE ARRAYS ARE NUMBERED FROM 1 TO 5
WAVE_A	ARRAY WHICH CONTAINS PERCENTAGES OF INITIAL UNITS REMAINING OF AGGRESSOR'S WAVES; THE ARRAYS ARE NUMBERED FROM 1 TO 5; COPY OF PREVIOUS ARRAY

COMMON VARIABLES

NAME	DEFINITION
X_	ARRAY WHICH CONTAINS X-AXIS COORDINATES OF UNITS IN LAND COMBAT PHASE; THE ARRAYS ARE NUMBERED FROM 1 TO 6
XA	ARRAY WHICH CONTAINS X-AXIS COORDINATES OF ALTERNATE FIRING POSITIONS FOR ALL DEFENSIVE UNITS IN LAND COMBAT PHASE
Y_	ARRAY WHICH CONTAINS Y-AXIS COORDINATES OF UNITS IN LAND COMBAT PHASE; THE ARRAYS ARE NUMBERED FROM 1 TO 6
YA	ARRAY WHICH CONTAINS Y-AXIS COORDINATES OF ALTERNATE FIRING POSITIONS FOR ALL DEFENSIVE UNITS IN LAND COMBAT PHASE

MAIN PROGRAM

NAME	DEFINITION
AMAX	TEMPORARY VARIABLE WHICH REPRESENTS THE MAXIMUM VALUE OF EITHER AXIS WHEN FUNCTION MAXVAL IS CALLED
CX_	CHECK VARIABLE FOR X-AXIS COORDINATES OF EACH UNIT; THE ARRAYS ARE NUMBERED FROM 1 THRU 6
CY_	CHECK VARIABLE FOR Y-AXIS CORRDINATES OF EACH UNIT; THE ARRAYS ARE NUMBERED FROM 1 THRU 6
FLAG	LOGICAL VARIABLE TO DETERMINE IF "DONEPL" IS CALLED
GXMAX	MAXIMUM VALUE OF X-AXIS ON GRID MAP
GXMAXA	MAXIMUM VALUE OF SECONDARY X-AXIS ON GRID MAP
GXTEMP	TEMPORARY VALUE OF THE NUMBER OF GRID LINES ON THE MAP FOR THE X-AXIS
GYMAX	MAXIMUM VALUE OF Y-AXIS ON GRID MAP
GYMAXA	MAXIMUM VALUE OF SECONDARY Y-AXIS ON GRID MAP
GYTEMP	TEMPORARY VALUE OF THE NUMBER OF GRID LINES ON THE MAP FOR THE Y-AXIS
IPAK	ARRAY WHICH CONTAINS THE PACK STORY FOR THE LINE GRAPH
IPKRAY	ARRAY WHICH CONTAINS THE PACK STORY FOR THE BAR CHART
J_	INCREMENTIAL VARIABLE FOR EACH UNIT; THE ARRAYS ARE NUMBERED FROM 1 THRU 6

MAIN PROGRAM

NAME	DEFINITION
LABEL1	LABEL LINE GRAPH FOR AGGRESSOR FORCES IN SHIP-TO-SHORE COMBAT PHASE
LABEL2	LABEL LINE GRAPH FOR DEFENSIVE FORCES IN SHIP-TO-SHORE COMBAT PHASE
LABEL3	LABEL LINE GRAPH FOR AGGRESSOR FORCES IN LAND COMBAT PHASE
LABEL4	LABEL LINE GRAPH FOR DEFENSIVE FORCES IN LAND COMBAT PHASE
QUIT	LOGICAL VARIABLE TO EXIT PROGRAM
XMAX	MAXIMUM X-AXIS VALUE FOR LINE GRAPH
XMAXA	ARRAY WHICH CONTAINS MAXIMUM VALUE OF X-AXIS FOR ALL UNITS IN LAND COMBAT PHASE
XORG	X-AXIS COORDINATE FOR LOWER LEFT CORNER OF A BLANKED RECTANGLE
YMAXA	ARRAY WHICH CONTAINS MAXIMUM VALUE OF Y-AXIS FOR ALL UNITS IN LAND COMBAT PHASE
YORG	Y-AXIS COORDINATE FOR LOWER LEFT CORNER OF A BLANKED RECTANGLE
YVAL	Y-AXIS COORDINATE OF VECTOR SPECIFIED IN AXIS UNITS

SUBROUTINE ANSWER

NAME	DEFINITION
BLANK	REPRESENTS A BLANK
DIGIT	ARRAY WHICH CONTAINS THE VALUE OF THE DIGITS FROM "0" TO "9"
DPOINT	REPRESENTS A DECIMAL POINT
LETTER	HAS THE VALUE OF THE FIRST NON-BLANK CHARACTER IN THE INPUT
LETY	REPRESENTS THE LETTER "Y"
NEGATE	LOGICAL VARIABLE WHICH IS SET TO .TRUE. WHEN A "Y" IS ENCOUNTED AS THE INPUT DATA
ZERO	REPRESENTS THE NUMBER "0"

SUBROUTINE CLEAR

NAME	DEFINITION
A	DUMMY LIST FOR INPUT OF DATA FROM TERMINAL

SUBROUTINE INITAL

NAME	DEFINITION
CHK	REPRESENTS THE REMAINDER OF THE "MOD" FUNCTION OF TWO NUMBERS
IEND	MAXIMUM VALUE OF TIME STEP FOR LINE GRAPH

SUBROUTINE PICTR

NAME	DEFINITION
I	BRANCHING VARIABLE AND PARAMETER FOR PICTUR
NPTST	NUMBER OF POINTS TO BE CONNECTED TO DRAW THE PICTURE OF THE TANK
TXARAY	ARRAY WHICH CONTAINS TANK'S X-AXIS COORDINATES
TXARY_	ARRAY WHICH CONTAINS THE X-AXIS COORDINATES FOR ALTERNATE FIRING POSITION SYMBOL; THE ARRAYS ARE NUMBERED FROM 1 TO 9
TYARAY	ARRAY WHICH CONTAINS TANK'S Y-AXIS COORDINATES
TYARY_	ARRAY WHICH CONTAINS THE Y-AXIS COORDINATES FOR ALTERNATE FIRING POSITION SYMBOL; THE ARRAYS ARE NUMBERED FROM 1 TO 9
XDPT	THE X COORDINATE IN INCHES OF THE SYMBOL ORIGIN
XP	ARRAY WHICH CONTAINS THE TRANSFORMED X-AXIS COORDINATES
YDPT	THE Y COORDINATE IN INCHES OF THE SYMBOL ORIGIN
YP	ARRAY WHICH CONTAINS THE TRANSFORMED Y-AXIS COORDINATES

FUNCTION VALMAX

NAME	DEFINITION
ARRAY	ARRAY WHICH CONTAINS THE INPUTTED ARRAY FROM THE FUNCTION CALL
NUM	UPPER BOUND ON THE "DO-LOOP"

APPENDIX B

INPUT DATA SET

for the

INTERACTIVE GRAPHICAL SUPPORT

and

A SMALL-UNIT AMPHIBIOUS OPERATION COMBAT MODEL

Due to the nature of this thesis, there exists two input data sets. The first input data set are associated with the small-unit amphibious operation combat model. The second input data set are associated with the interactive graphical support. Each data set is discussed separately and followed by its computer file listing.

A. SMALL-UNIIT AMPHIBIOUS OPERATION COMBAT MODEL DATA SET

The small-unit amphibious operation combat model requires data for each of the two phases of combat. The input data for these combat phases are listed in the SEA1 DATA file for the ship-to-shore combat phase and in the LAND DATA file for the land combat phase. Also available to the user is a blank file for both of the combat phases which are the BSEA1 DATA file for the ship-to-shore combat phase and the BLAND DATA file for the land combat phase. The two blank data files are utilized when the user wishes to input a totally different data base for the model. If the user wants to change only a few of the input data items, he would utilize the complete data files. The four files list the descriptive name along side of the input data item providing the user a means of associating the input data item with

their respective input variable. A copy of each of the input data files follows in the order of SEA1, LAND, BSEA1, and BLAND.

```
LVA'S   SPDMAX = 40.00 SPDMIN =10.5 HTMAX = 1.7 HTMIN = 0.6 WIDTH = 3.533
TANK MAX RANGE =   1500. ATGM MAX RANGE =  2000. ATGM MIN RANGE =   200.
        TARTM = 15.      SARTM = 30.  TVEL  = 350. SVEL = 350.
TSIGV = 25.        500.        1000.       2000.       5000.       10000.          0.
         2.          5.          20.         25.         25.
TSIGH = 25.        500.        1000.       2000.       5000.       10000.          0.
         2.          5.          20.         25.         25.
TMENH = 25.        500.        1000.       2000.       5000.       10000.          0.
         1.          5.          10.         15.         15.
SSIGV = 25.        250.         500.       1000.       2500.        5000.      10000.
         0.          5.           7.5        14.         15.5         17.         20.
SSIGH = 25.        250.         500.       1000.       2500.        5000.      10000.
         0.          5.           7.5        14.         15.5         17.         20.
DEF. WEIGHTS ASSIGNED TO WAVE ONE =       2.  AND WAVE TWO =     1.
     NO. OF LVA PER WAVE = 25.         20.         15.          10.          5.
 SHORE DEF. TANK ASSETS =              10.  ATGM ASSETS =     10.
DEF FORCE ATTRIT COEF. FOR TANK FIRE:  ALPHA = 0.00006 AND BETA = 0.00008
                  AND FOR ATGM FIRE:   ALPHA = 0.0007  AND BETA = 0.0009
      AIMED FIRE ATTRIT COEF.:      WBETA(1) =  0.0005  WBETA(2) = 0.0007
          GAINL =  0.32
          GAMMA =  50.0         DELTA = 100.0
     NO. OF HILLS IN TERRAIN MODEL =  46
            BASE = 0.0
HILL DATA:XC= 2000.  YC= 1100.  PEAK= 170.  ANGH=   0.1 SPRD= 999.9   ECC= 8.0
              1800.      2200.        150.         30.        350.         2.0
              2000.      1900.        150.        130.        300.         2.
              2400.      1400.        150.          0.1       300.         2.5
              2450.      1700.        130.         80.        500.         2.2
              2700.      1800 .       138.         90.        500.         2.2
              3200.      1650.        140.        150.        600.         3.
              4300.      1300.        130.        160.        400.         3.5
              3750.      1750.        150.          0.1       660.         3.6
              4150.      1600.        150.        160.        550.         3.
              3200.      2150.        130.         25.        500.         1.5
              4600.      1700.        170.         45.        300.         2.5
              4800.      1500.        170.          0.1       300.         2.5
              2200.      2600.        170.         90.        350.         1.8
              2400.      2850.        150.        120.        300.         1.8
              3100.      2700.        150.        150.        350.         2.
              2500.      2400.        150.          0.1       250.         1.0
              2650.      2850.        150.        160.0       400.         3.0
              2700.      2600.        150.        130.        370.         1.8
              3800.      2200.        150.          0.1       230.         1.5
              4500.      2600.        150.         90.        280.         1.3
              3600.      2800.        150.        145.        500.         2.5
              2700.      3300.        190.         25.        350.         2.0
              3000.      3300.        170.         15.        400.         2.5
              3150.      3750.        130.          0.1       350.         2.5
              3750.      3200.        150.         10.        850.         5.0
              3800.      3800.        150.          0.1       650.         3.
              3600.      3600.        150.        160.        320.         2.0
              4150.      3950.        170.         30.        220.         2.2
              1650.      2100.        150.         30.        300.         2.0
              2250.      2100.        180.        150.        220.         1.2
              2200.      1700.        180.         80.        150.         1.5
              2800.      1400.        150.        165.        500.         2.7
              3800.      2650.        150.         20.        400.         2.5
              4150.      3000.        130.        160.        300.         1.7
              4450.      3150.        130.        140.        350.         2.5
              4850.      3600.        150.         45.        400.         1.8
              4500.      4000.        150.         60.        450.         2.
              4850.      3450.        150.        150.        440.         1.8
              4900.      3000.        130.         45.        250.         1.5
              4700.      2400.        150.         50.        400.         2.5
              4900.      2000.        130.          0.1       250.         1.5
              2500.      1100.        170.          0.1       950.         8.
              3350.      4300.        150.         45.        450.         2.5
              4000.      2200.        150.         45.        280.         2.
              3900.      2200.        150.          0.1       300.         3.5
     LST(5,4)  =    0     0     0     0     0     0     1     7    18    27
                    0    33    39    53    62     0    74    77    83    93
     NHL(5,4)  =    0     0     0     0     0     0     6    11     9     6
```

```
                     0     6    14     9    12     0     3     6    10     9
NO. OF HILLS TOTAL =                       101
LISTH(I)  =          1     2     3    30     4    43     1     3     4     5
                     6    32    33     7    11    31    43     1     6     7
                     8     9    10    11    33    43    10    12    13     9
                     8    42     2    14    30    23    15     3    14    15
                    16    17    18    19    20     3     6    23    11     7
                     2    31    11    16    20    22    34    35    44    45
                    46    20    21    22    12    34    35    36    40    41
                    42    45    46    14    23    15    23    24    25    15
                    26    14    25    26    27    28    29    24    22    23
                    35    44    26    27    29    35    36    37    38    39
                    40
NCVELS =                                     0
```

```
    ATTRIT VAR =    0     DSPEED =     143257.0   (FOR AGGRESSOR FORCES)
 BETA DIST. INPUT PARAMETERS:   PP =              5.0  QQ =           25.0
    ATTRIT VAR =    0     DSPEED =     123457.0   (FOR DEFENSIVE FORCES)
 BETA DIST. INPUT PARAMETERS:   PD =             25.0  QD =            5.0
 NO. DEF UNITS =  03   NO. ATK UNITS = 03
  RMINTK = 0000.0    RMXTK = 2500.0 RMINTW   = 0500.0    RMXTW = 4000.0
   TYPE OF ROUTE = 1    VEHICLE SPEED = 4
          X =   2000.0            Y =   1900.0
                1900.0                  2400.0
                1500.0                  2100.0
   NO. OF NODES FOR ROUTE 1 =               01
  XLOC(1,1)=    5000.0   YLOC(1,1) =  2500.0      FOR NODE 1 OF ROUTE 1
   NO. OF NODES FOR ROUTE 2 =               01
  XLOC(2,1)=    4900.0   YLOC(2,1) =  2150.0      FOR NODE 1 OF ROUTE 2
   NO. OF NODES FOR ROUTE 3 =               02
  XLOC(3,1)=    2200.0   YLOC(3,1) =  1700.0      FOR NODE 1 OF ROUTE 3
  XLOC(3,2)=    4800.0   YLOC(3,2) =  1750.0      FOR NODE 2 OF ROUTE 3
DEF UNIT X =    3800.0            Y =   2700.0 FORCE10.0  DIR. 190 WIDTH 120
    I           3800.0                  2300.0 LEVEL 5.0   OF  190   OF  120
LOCATION        3600.0                  1700.0     10.0  MVMT 180  SRCH 120
    ALT. POS.  VAR. 0      BREAK PT   0500.0 NO. TIME STEPS FOR MOVE      4
      XA(1)  =  4500.0       YA(1)  =  3800.0 FOR ALT. POS. 1
      XA(2)  =  4500.0       YA(2)  =  2700.0  =   =     =   2
          X  =  4600.0           Y  =  1800.0  =   =     =   3
       0.60         0.70        0.65        0.85
       0.85         0.90        0.85        0.90
       0.80         0.85        0.85        0.80
       0.75         0.80        0.75        0.70
       0.60         0.70        0.65        0.65
       0.40         0.45        0.40        0.50
     P 0.85    PHH  0.85   PHM  0.75   PKH  0.70
       0.80         0.80        0.75        0.70
       0.75         0.75        0.70        0.60
       0.60         0.65        0.60        0.55
       0.45         0.50        0.50        0.35
       0.20         0.20        0.20        0.20
```

```
FILE: BSEA1    DATA     A   NAVAL POSTGRADUATE SCHOOL

LVA'S    SPDMAX = __.__  SPDMIN = _._  HTMAX = _._  HTMIN = _._  WIDTH = _.___
             TTS = __.     LENGTH OF EACH TIME STEP IN SECONDS.
TANK MAX RANGE = ____.  ATGM MAX RANGE = ____.  ATGM MIN RANGE = ___.
           TARTM = __.    SARTM = __.   TVEL = __.  SVEL = ___.
TSIGV = __.      ___.      ____.      ____.      ____.      _____.      _.
TSIGH = __.      ___.      ____.      ____.      ____.      _____.      _.
TMENH = __.      ___.      ____.      ____.      ____.      _____.      _.
SSIGV = __.      ___.      ___.       ____.      ____.      ____.       _____.
SSIGH = __.      ___.      ____.      ____.      ____.      ____.       _____.
DEF. WEIGHTS ASSIGNED TO WAVE ONE =     __.  AND WAVE TWO =    __.      __.
       NO. OF LVA PER WAVE = __.
 SHORE DEF. TANK ASSETS =               __.  ATGM ASSETS =  __.         __.
ATTRIT COEF. FOR AGGRESSOR FORCE FIRE: ALPHA1= _._____    ALPHA2 = _._____
ATTRIT COEF. FOR DEFENSIVE FORCE FIRE: BETA1 = _._____     BETA2  = _._____
      AIMED FIRE ATTRIT COEF.:     WBETA(1) = _._____  WBETA(2) = _._____
          GAINL =    _.__
         GAMMA =    _.          DELTA =    _._
    NO. OF HILLS IN TERRAIN MODEL = 40
            BASE = 0.0
HILL DATA:XC= 2000.  YC= 1100.  PEAK= 170.  ANGH=  0.1  SPRD= 999.9   ECC= 8.0
              1800.      2200.        150.        30.          350.          2.0
              2000.      1900.        150.       130.          300.          2.
              2400.      1400.        150.         0.1         300.          2.5
              2450.      1700.        130.        80.          500.          2.2
              2700.      1800 .       138.        90.          500.          2.2
              3200.      1650.        140.       150.          600.          3.
              4300.      1300.        130.       160.          400.          3.5
              3750.      1750.        150.         0.1         660.          3.6
              4150.      1600.        150.       160.          550.          3.
              3200.      2150.        130.        25.          500.          1.5
              4600.      1700.        170.        45.          300.          2.5
              4800.      1500.        170.         0.1         300.          2.5
              2200.      2600.        170.        90.          350.          1.8
              2400.      2850.        150.       120.          300.          1.8
              3100.      2700.        150.       150.          350.          2.
              2500.      2400.        150.         0.1         250.          1.0
              2650.      2850.        150.       160.0         400.          3.0
              2700.      2600.        150.       130.          370.          1.8
              3800.      2200.        150.         0.1         230.          1.5
              4500.      2600.        150.        90.          280.          1.3
              3600.      2800.        150.       145.          500.          2.5
              2700.      3300.        190.        25.          350.          2.0
              3000.      3300.        170.        15.          400.          2.5
              3150.      3750.        130.         0.1         350.          2.5
              3750.      3200.        150.        10.          850.          5.0
              3800.      3800.        150.         0.1         650.          3.
              3600.      3600.        150.       160.          320.          2.0
              4150.      3950.        170.        30.          220.          2.2
              1650.      2100.        150.        30.          300.          2.0
              2250.      2100.        180.       150.          220.          1.2
              2200.      1700.        180.        80.          150.          1.5
              2800.      1400.        150.       165.          500.          2.7
              3800.      2650.        150.        20.          400.          2.5
              4150.      3000.        130.       160.          300.          1.7
              4450.      3150.        130.       140.          350.          2.5
              4850.      3600.        150.        45.          400.          1.8
              4500.      4000.        150.        60.          450.          2.
              4850.      3450.        150.       150.          440.          1.8
              4900.      3000.        130.        45.          250.          1.5
              4700.      2400.        150.        50.          400.          2.5
              4900.      2000.        130.         0.1         250.          1.5
              2500.      1100.        170.         0.1         950.          8.
              3350.      4300.        150.        45.          450.          2.5
              4000.      2200.        150.        45.          280.          2.
              3900.      2200.        150.         0.1         300.          3.5
    LST(5,4)  =    0      0      0      0      0      0     1     7     18    27
                   0     33     39     53     62      0    74    77     83    93
```

```
NHL(5,4)  =      0     0     0     0     0     0     6    11     9     6
                 0     6    14     9    12     0     3     6    10     9
NO. OF HILLS TOTAL =                   101
LISTH(I)  =      1     2     3    30     4    43     1     3     4     5
                 6    32    33     7    11    31    43     1     6     7
                 8     9    10    11    33    43    10    12    13     9
                 8    42     2    14    30    23    15     3    14    15
                16    17    18    19    20     3     6    23    11     7
                 2    31    11    16    20    22    34    35    44    45
                46    20    21    22    12    34    35    36    40    41
                42    45    46    14    23    15    23    24    25    15
                26    14    25    26    27    28    29    24    22    23
                35    44    26    27    29    35    36    37    38    39
                40
NCVELS =                                 0
```

```
    ATTRIT VAR =          DSEED =  ______._   (FOR AGGRESSOR FORCES)
 BETA DIST. INPUT PARAMETERS:  PP =             .  QQ =          .
    ATTRIT VAR =          DSEED =  ______._   (FOR DEFENSIVE FORCES)
 BETA DIST. INPUT PARAMETERS:  PD =         __._  QD =          _._
 NO. DEF UNITS =  __   NO. ATK UNITS =
  RMINTK =    .    RMXTK =    .   RMINTW  = ____._    RMXTW = ____._
   TYPE OF ROUTE = _    VEHICLE SPEED =__
  XIC(1,1) =  ____._  YIC(1,1)  =  ____._
              ____._               ____._
                  .                ____._
   NO. OF NODES FOR ROUTE    =
  XLOC(1,1)=      .    YLOC(1,1) =  ____._     FOR NODE 1 OF ROUTE 1
   NO. OF NODES FOR ROUTE    =
  XLOC(2,1)=      .    YLOC(2,1) =  ____._     FOR NODE 1 OF ROUTE 2
   NO. OF NODES FOR ROUTE    =
  XLOC(3,1)=  ____._   YLOC(3,1) =  ____._     FOR NODE 1 OF ROUTE 3
  XLOC(3,2)=  ____._   YLOC(3,2) =  ____._     FOR NODE 2 OF ROUTE 3
DEF UNIT X =  ____._             Y =  ____._ FORCE__._  DIR. ___  WIDTH ___
    I         ____._                  ____._ LEVEL__._   OF          OF
LOCATION      ____._                  ____._      .      FIRE ___   SRCH ___
    ALT. POS. VAR. _     BREAK PT     ____._ NO. TIME STEPS FOR MOVE     _
     XA(1) =  ____._       YA(1)  =   ____._ FOR ALT. POS. 1
     XA(2) =  ____._       YA(2)  =   ____._  =    =     =  2
         X =  4600.0           Y  =   ____._  =    =     =  3
      _.__       _.__       _.__       _.__
      _.__       _.__       _.__       _.__
      _.__       _.__       _.__       _.__
      _.__       _.__       _.__       _.__
   P  _.__   PHH _.__   PHM _.__   PKH _.__
      _.__       _.__       _.__       _.__
      _.__       _.__       _.__       _.__
      _.__       _.__       _.__       _.__
      _.__       _.__       _.__       _.__
      _.__       _.__       _.__       _.__
```

B. INTERACTIVE GRAPHICAL SUPPORT DATA SET

The interactive graphical support program requires specific data from the small-unit amphibious operation combat model. Upon execution of the combat model, the data needed for the support program are found on various files. The names of these files are associated to a degree with the type of data within them. A brief explanation of each file follows with an example of each file presented after the discussion of all the files.

1. ALTCORD Output File

ALTCORD output file contains the coordinates of the alternate firing positions of the defensive forces in the land combat phase. There are two columns in the file with the left column representing the x-axis coordinates and the right column representing the y-axis coordinates of the positions. Each row represents a defensive unit (i.e. row 1 - unit 4; row 2 - unit 5; row 3 - unit 6).

2. FINALGRD Output File

FINALGRD output file lists the attrition at the termination of the battle for all the units in the land combat phase. The first row represents the units 1, 2, 3, and 4 while the second row represents the units 5 and 6.

3. FINALSEA Output File

FINALSEA output file has the same function as the previous file except the values in this file are for the units involved in the ship-to-shore combat phase. Presently, there are seven units in this phase. Thus, the numbering sequence for the first row represents wave 1 through wave 4 and the second row represents wave 5, tank, and ATGM.

4. IGRAF Data File

IGRAF data file consists of the data relating to the time step, total time step, and ending time for each phase of the battle. Each variable in this file is listed with a description of it. These variables are used in the line graph and bar chart features of the support program.

5. LVATAT Number File

LVATAT number file contains the LVA, tank and ATGM numbers assigned to these forces by the user in the SEA1 data file. These numbers are utilized to establish the secondary y-axis labels on the line graph for the ship-to-shore combat phase.

6. TOTALGRD Output File

TOTALGRD output file contains the attrition percentage per time step remaining of each unit within the land combat phase. These percentages are utilized to provide the y-axis values for the line graph for the land combat phase.

7. TOTALSEA Output File

TOTALSEA output file contains the attrition percentage per time step remaining of each unit within the ship-to-shore combat phase. These percentages provide the same usage as expressed in the previous section.

8. UNITS Number File

UNITS number file contains the initial unit strength of each unit in the land combat phase. These numbers are used to establish the secondary y-axis of the line graph for the land combat phase.

9. XCORD Output File

XCORD output file contains the x-axis coordinate value per time step of each unit in the land combat phase. These coordinates in conjunction with the y-axis coordinates are utilized to determine the location for placing the center of the unit's symbol: tank. Additionaly, these coordinates determine the location for the primary firing position symbol of the defensive forces' units 4 through 6.

10. YCORD Output File

YCORD output file is the other half of the coordinate system needed to determine the location of each unit. This file and the XCORD output file together provide the x and y coordinates utilized in the grid map for various functions as discussed in the previous section.

```
FILE: ALTCORD  OUTPUT  A  NAVAL POSTGRADUATE SCHOOL

 4500.0  3800.0
 4500.0  2700.0
 4600.0  1800.0
```

```
FILE: FINALGRD OUTPUT  A  NAVAL POSTGRADUATE SCHOOL

  71.9420776        98.8007965        100.000000        100.000000
  100.000000        .0
```

```
FILE: FINALSEA OUTPUT  A  NAVAL POSTGRADUATE SCHOOL

  75.9999347        84.9999847        86.6666565        100.000000
  100.000000        .0                .0
```

```
FILE: IGRAF    DATA    A  NAVAL POSTGRADUATE SCHOOL

 TIME STEP FOR SHIP-TO-SHORE PHASE          =    30.0
 ENDING TIME FOR SHIP-TO-SHORE PHASE        =    445
 TOTAL TIME STEPS FOR SHIP-TO-SHORE PHASE   =    46.0
 TIME STEP FOR LAND COMBAT PHASE            =    20.0
 LAND COMBAT ATTACK TIME                    =   440.0
 BEGINNING TIME FOR LAND COMBAT PHASE       =    460
 ENDING TIME FOR LAND COMBAT PHASE          =    520
 TOTAL TIME STEPS FOR LAND COMBAT PHASE     =     5.0
```

```
FILE: LVATAT   NUMBER  A  NAVAL POSTGRADUATE SCHOOL

  25.0000000        20.0000000        15.0000000        10.0000000
  5.00000000        10.0000000        10.0000000
```

```
FILE: TOTALGRD OUTPUT  A  NAVAL POSTGRADUATE SCHOOL

 100.0 100.0 100.0 100.0 100.0 100.0
 100.0 100.0 100.0 100.0 100.0 100.0
 100.0 100.0 100.0 100.0 100.0 100.0
  78.3 100.0 100.0 100.0 100.0  36.9
  71.9  98.8 100.0 100.0 100.0   0.0
```

100.0	100.0	100.0	100.0	100.0	100.0	100.0
100.0	100.0	100.0	100.0	100.0	99.9	99.9
100.0	100.0	100.0	100.0	100.0	99.9	99.8
100.0	100.0	100.0	100.0	100.0	99.8	99.8
100.0	100.0	100.0	100.0	100.0	99.8	99.7
100.0	100.0	100.0	100.0	100.0	99.7	99.6
100.0	100.0	100.0	100.0	100.0	99.6	99.5
100.0	100.0	100.0	100.0	100.0	99.6	99.4
100.0	100.0	100.0	100.0	100.0	99.5	99.4
100.0	100.0	100.0	100.0	100.0	99.5	99.3
100.0	100.0	100.0	100.0	100.0	99.4	99.2
100.0	100.0	100.0	100.0	100.0	99.3	99.1
92.0	100.0	100.0	100.0	100.0	99.3	99.0
76.0	100.0	100.0	100.0	100.0	98.9	98.6
76.0	100.0	100.0	100.0	100.0	97.9	97.2
76.0	100.0	100.0	100.0	100.0	96.9	95.7
76.0	100.0	100.0	100.0	100.0	95.9	94.3
76.0	100.0	100.0	100.0	100.0	94.8	92.9
76.0	100.0	100.0	100.0	100.0	93.8	91.5
76.0	100.0	100.0	100.0	100.0	92.7	90.1
76.0	100.0	100.0	100.0	100.0	91.7	88.6
76.0	100.0	100.0	100.0	100.0	90.6	87.2
76.0	100.0	100.0	100.0	100.0	89.6	85.8
76.0	100.0	100.0	100.0	100.0	88.5	84.4
76.0	90.0	100.0	100.0	100.0	87.4	83.0
76.0	85.0	100.0	100.0	100.0	86.1	81.2
76.0	85.0	100.0	100.0	100.0	84.2	78.6
76.0	85.0	100.0	100.0	100.0	82.2	76.0
76.0	85.0	100.0	100.0	100.0	80.1	73.4
76.0	85.0	100.0	100.0	100.0	78.1	70.8
76.0	85.0	100.0	100.0	100.0	76.0	68.2
76.0	85.0	100.0	100.0	100.0	73.9	65.6
76.0	85.0	100.0	100.0	100.0	71.8	63.0
76.0	85.0	100.0	100.0	100.0	69.7	60.4
76.0	85.0	100.0	100.0	100.0	67.5	57.7
76.0	85.0	100.0	100.0	100.0	65.4	55.1
76.0	85.0	93.3	100.0	100.0	63.1	52.5
76.0	85.0	86.7	100.0	100.0	60.7	49.7
76.0	85.0	86.7	100.0	100.0	57.6	46.2
76.0	85.0	86.7	100.0	100.0	54.5	42.7
76.0	85.0	86.7	100.0	100.0	51.2	39.1
76.0	85.0	86.7	100.0	100.0	47.9	35.6
76.0	85.0	86.7	100.0	100.0	44.5	32.1
76.0	85.0	86.7	100.0	100.0	41.0	28.6
76.0	85.0	86.7	100.0	100.0	37.4	25.1
76.0	85.0	86.7	100.0	100.0	0.0	0.0

```
FILE: YCORD     OUTPUT    A    NAVAL POSTGRADUATE SCHOOL

   1900.0   2400.0   2100.0   2700.0   2300.0   1700.0
   1915.8   2393.3   2060.1   2700.0   2300.0   1700.0
   1931.6   2386.6   2020.2   2700.0   2300.0   1700.0
   1947.3   2380.0   1980.2   2700.0   2300.0   1700.0
   1947.3   2373.3   1940.3   2700.0   2300.0   1700.0
```

```
FILE: UNITS     NUMBER    A    NAVAL POSTGRADUATE SCHOOL

    21.0000000          21.0000000          21.0000000          10.0000000
    5.00000000          10.0000000
```

```
FILE: XCORD     OUTPUT    A    NAVAL POSTGRADUATE SCHOOL

   2000.0   1900.0   1500.0   3800.0   3800.0   3600.0
   2078.9   1980.2   1569.9   3800.0   3800.0   3600.0
   2157.8   2060.4   1639.7   3800.0   3800.0   3600.0
   2236.7   2140.5   1709.6   3800.0   3800.0   3600.0
   2236.7   2220.7   1779.4   3800.0   3800.0   3600.0
```

APPENDIX C

EXECUTIVE PROGRAM

for the

INTERACTIVE GRAPHICAL SUPPORT

and

A SMALL-UNIT AMPHIBIOUS OPERATION COMBAT MODEL

The executive program, WAR1 EXEC, is designed to provide an interface between the small-unit amphibious operation combat model and the interactive graphical support program. The sequence of events within the executive program are:

1. Compile the small-unit amphibious operation model and the interactive support programs.
2. Erase the listings of the two programs.
3. Establish the file definitions required for the two programs.
4. Load and execute the model.
5. Access DISSPLA EXEC which loads and executes the interactive graphical support.
6. Print the battle summary contained in AMPHIB1 LISTING file.
7. Browse the AMPHIB1 LISTING file.
8. Exit when the user is finished.

The executive program provides the user with a display of the above sequence of events after he types in WAR1. After reading the above sequence of events and pressing the enter key, the executive program begins the first event above. This event compiles the small-unit amphibious operation combat model first, and upon completion of compilation, the executive program starts to compile the interactive graphical support program. When this compilation is completed, the executive program erases the two listings generated by the compilation process because of the percentage of disk space consumed by these listings. The next event accesses

precompiled libraries and establishs the definitions of files required by the two programs. These files are required for each retrieving and writting data. Upon completion of this event, the executive program loads and starts the small-unit amphibious operation combat model. When the model has completed its processing, the executive program queries the user regarding whether or not he wishes to run the interactive graphical support program. If he does, DISSPLA EXEC is accessed which loads and starts the program. If he does not, the executive program branches to the next query regarding the printing of the battle summary. Again the user is asked to respond to a question, this time determining whether he wants a copy of the battle summary. Once the user decides, the program will either print the battle summary or branch to the next query. The next query is the seventh event which also questions the user regarding whether he wishes to examine the AMPHIB1 LISTING. Upon execution of the user's answer, the final event is questioning the user if he wishes to exit the executive program or run the model again. Depending upon the answer, the executive program will either continue the processing of events beginning with number three or terminate the executive program. A listing of the executive program follows on the next page.

```
&TRACE
*
*      THIS EXEC WILL PERFORM THE FOLLOWING:
*            1. COMPLIE "WAR1" AND "GRAPIT" FORTRAM PROGRAMS
*            2. ERASE "WAR1" AND "GRAFIT" LISTINGS
*            3. FILEDEF APPROPRIATE FILES FOR THE TWO PROGRAMS
*            4. LOAD AND START "WAR1" PROGRAM
*            5. ACCESS DISSPLA EXEC TO LOAD AND START "GRAFIT" PROGRAM
*            6. PRINT AMPHIB1 LISTING
*            7. BROWSE THE AMPHIB1 LISTING
*            8. EXIT EXEC WILL USER IS FINISHED
*
&BEGTYPE -ENDTELL
          THIS EXECUTIVE PROGRAM WILL :

                1.  COMPILE TWO FORTRAN SOURCE PROGRAMS -
                    "WAR1" AND "GRAFIT" USING THE "FORTGI" COMPILER
                2.  ERASE THE "WAR1" AND "GRAFIT" LISTINGS
                3.  DEFINE THE FILES REQUIRED FOR THE TWO PROGRAMS
                4.  LOAD AND EXECUTE THE "WAR1" PROGRAM
                5.  ACCESS "DISSPLA" WHICH WILL LOAD AND EXECUTE
                    THE "GRAFIT" PROGRAM
                6.  PRINT BATTLE SUMMARY CONTAINED IN "AMPHIB1
                    LISTING" FILE
                7.  BROWSE THE "AMPHIB1 LISTING" FILE
                8.  EXIT WHEN USER IS FINISHED
-ENDTELL
&BEGTYPE -PRESS

          ****   PRESS ENTER TO CONTINUE  ****
-PRESS
&READ VAR
CLRSCRN
*
*      COMPILE THE TWO PROGRAMS
*
&BEGTYPE -ENDCP1

                .... COMPILING OF "WAR1" PROGRAM BEGINS ....

-ENDCP1
FORTGI WAR1
&BEGTYPE -PRESS1

          ****   PRESS ENTER TO CONTINUE  ****
-PRESS1
&READ VAR
ERASE WAR1 LISTING
CLRSCRN
&BEGTYPE -ENDCP2

               .... COMPILING OF "GRAFIT" PROGRAM BEGINS ....

-ENDCP2
FORTGI GRAFIT
&BEGTYPE -PRESS2

          ****   PRESS ENTER TO CONTINUE  ****
-PRESS2
&READ VAR
ERASE GRAFIT LISTING
CLRSCRN
&BEGTYPE -SETUP

               .... WAR1 FORTRAN PROGRAM IS BEING LOADED ....
                    .... EXECUTION WILL SOON FOLLOW ....

-SETUP
-A
*
*      SET UP FILE DEFINITIONS FOR THE TWO PROGRAMS
*
```

```
GLOBAL TXTLIB FORTMOD2 MOD2EEH IMSLSP NONIMSL CMSLIB
FILEDEF 01 DISK TOTALSEA OUTPUT (PERM
FILEDEF 02 DISK FINALSEA OUTPUT (PERM
FILEDEF 03 DISK TOTALGRD OUTPUT (PERM
FILEDEF 04 DISK FINALGRD OUTPUT (PERM
FILEDEF 05 DISK SEA1 DATA
FILEDEF 06 DISK AMPHIB1 LISTING
FILEDEF 07 TERM
FILEDEF 08 TERM
FILEDEF 09 DISK LAND DATA
FILEDEF 32 DISK IGRAF DATA (PERM
FILEDEF 33 DISK LVATAT NUMBER (PERM
FILEDEF 34 DISK UNITS NUMBER ( PERM
FILEDEF 35 DISK XCORD OUTPUT (PERM
FILEDEF 36 DISK YCORD OUTPUT (PERM
FILEDEF 37 DISK ALTCORD OUTPUT (PERM
*
*     LOAD AND EXECUTE THE "WAR1" PROGRAM
*
LOAD WAR1 ( START
*
&BEGTYPE -WAR

            ****  THIS CONCLUDES THE WAR1 PROGRAM  ****

-WAR
&BEGTYPE -PRESS3

                 ****  PRESS ENTER TO CONTINUE  ****

-PRESS3
&READ VAR
*
*     ASK USER IF WISH TO EXECUTE "GRAFIT" PROGRAM
*     IF YES, BRANCH TO -B TO EXECUTE THE PROGRAM
*     IF NO, BRANCH TO -C TO QUESTION USER AGAIN
*
CLRSCRN
&BEGTYPE -QUEST1
        DO YOU WISH TO EXECUTE "GRAFIT" PROGRAM?
                     ANSWER  Y  OR  N
-QUEST1
&READ VAR &ANS
&IF /&ANS = /Y &GOTO -B
&GOTO -C
-B CLRSCRN
EXEC DISSPLA GRAFIT
-C CLRSCRN
*     QUESTION USER IF HE WISHES TO PRINT CURRENT VERSION OF
*     "AMPHIB1 LISTING" FILE WHICH CONTAINS THE "BATTLE SUMMARY"
*     IF YES, PRINT FILE
*     IF NO, BRANCH TO -D
*
&BEGTYPE -QUEST2

         AMPHIB1 LISTING FILE CONTAINS THE BATTLE SUMMARY
         OF WAR1 PROGRAM.
         IF YOU WISH TO RUN THE MODEL AGAIN, THE CURRENT
         BATTLE SUMMARY WILL BE WRITTEN OVER.

         DO YOU WISH TO PRINT THE CURRENT "AMPHIB1 LISTING" FILE?
                      ANSWER  Y  OR  N
-QUEST2
&READ VAR &ANS
&IF /&ANS ¬= /Y &GOTO -D
PRINT AMPHIB1 LISTING
CLRSCRN
&BEGTYPE -PRINT
         ....  FILE ENTERED INTO VM PRINTER QUEUE  ....
            ....  AVAILABLE FOR PICK UP SHORTLY  ....
-PRINT
&BEGTYPE -PRESS4
```

```
                    ****  PRESS ENTER TO CONTINUE  ****

-PRESS4
&READ VAR
-D CLRSCRN
&BEGTYPE -QUEST3
            DO YOU WISH TO BROWSE THE "AMPHIB1 LISTING" FILE?
                                  ANSWER  Y  OR  N
-QUEST3
&READ VAR &ANS
&IF /&ANS ¬= /Y &GOTO -E
BROWSE AMPHIB1 LISTING
*       QUESTION USER IF HE WANTS TO RUN MODEL AGAIN
*       IF YES, BRANCH TO -A
*       IF NO, EXIT EXECUTIVE FILE
*
-E CLRSCRN
&BEGTYPE -QUEST4
            DO YOU WISH TO EXECUTE THE MODEL ("WAR1" PROGRAM) AGAIN?
                                      ANSWER  Y  OR  N
-QUEST4
&READ VAR &ANS
&IF /&ANS = /Y &GOTO -A
CLRSCRN
&BEGTYPE -END

               ....  THIS CONCLUDES THE EXECUTIVE PROGRAM  ....
                                  ....  GOOD DAY  ....
-END
&EXIT
```

APPENDIX D

MODEL AND GRAPHICS OUTPUT

for the

INTERACTIVE GRAPHICAL SUPPORT

and

A SMALL-UNIT AMPHIBIOUS OPERATION COMBAT MODEL

The output generated by the small-unit amphibious operation combat model and the interactive graphical support are two different facets of computer science. The model's output is a computerized output consisting of alphanumerical characters, whereas the support program's output deals with graphical representation of data generated by the model. Thus, a unique and supportive analysis of the input data is provided with the utilization of both forms of output. The user is better able to visualize and analyze the output data with this combination of outputs.

A. MODEL'S OUTPUT

The small-unit amphibious operation combat model's output is a computerized listing consisting of alphanumeric characters. This output reports on each phase of combat. Each phase's output is broken down into two parts. The first part is the initial information which is a representation of the input data. The purpose for this reprinting is to act as a record of the scenario that the model analyzes, and as a check for the user to verify that the data were inputted correctly by the program. The second part is the battle summary where the detail of this part is determined by the user. Depending upon which option the user selects,

the battle summary is produced for each time step or for the final time step. The battle summary reports on the status of both the aggressor and defensive forces during the battle. The example of the output which follows is based upon the input data listed in Appendix B.

```
** INITIAL SHIP-TO-SHORE PHASE INFORMATION **

     INITIAL FORCE STRENGTH
WAVE  1      2      3      4      5
LVA  25.0  20.0  15.0  10.0    5.0

DEF. TANK ASSETS = 10.0      DEF. ATGM ASSETS = 10.0

LVA ENGR SPECS
SPDMAX  SPDMIN   HTMAX  HTMIN   WID
 40.00   10.50    1.70   0.60  3.53

DEFENSIVE TACTICAL PARAMETERS
          RANGE     AIM-RELOAD    PROJECTILE
       MAX    MIN      TIME        VELOCITY
TANK 1500.0           15.00         350.00
ATGM 2000.0  200.0   30.00         350.00

DEFENSIVE TACTICAL ALLOCATION WEIGHTS:
WAVE 1 =  2.00 WAVE 2 =  1.00

DEFENSIVE FORCE ATTRITION COEFFICIENTS
         ALPHA*A          BETA*A
DT       0.00006          0.00070
DS       0.00008          0.00090

AIMED FIRE ATTRITION RATE COEFFICIENTS FOR
      DEFENSIVE TANK AND ATGM ASSETS

WBETA(1)=0.00050 WBETA(2)=0.00070

BREAKPOINT ASSUMPTION: 0.3*(TOTAL DEF FORCE)

DEFENDER ATTRITION LEVEL ALLOWING FOR LAND COMBAT
 0.32*(TOTAL DEFENDER FORCE)

ARTM SUP FACTOR= 50.0  ERROR SUP FACTOR=100.0

DISPERSION DATA

  RANGE   TSIGV  RANGE   TSIGH   RANGE   TMEANH
   25.0     0.0    25.0    0.0     25.0    0.0
  500.0     2.0   500.0    2.0    500.0    1.0
 1000.0     5.0  1000.0    5.0   1000.0    5.0
 2000.0    20.0  2000.0   20.0   2000.0   10.0
 5000.0    25.0  5000.0   25.0   5000.0   15.0
10000.0    25.0 10000.0   25.0  10000.0   15.0

  RANGE   SSIGV  RANGE   SSIGH
   25.0     0.0    25.0    0.0
  250.0     5.0   250.0    5.0
  500.0     7.5   500.0    7.5
 1000.0    14.0  1000.0   14.0
 2500.0    15.5  2500.0   15.5
 5000.0    17.0  5000.0   17.0
10000.0    20.0 10000.0   20.0

CURRENT STATUS OF WAVE I VARIABLE DEFINITIONS

0 - NOT ENGAGING
1 - LANDED
2 - UNDER FIRE BY ATGM
3 - UNDER FIRE BY TANK
4 - UNDER FIRE BY BOTH ATGM & TANK
```

```
***** THE SHIP-TO-SHORE PHASE BEGINS *****

BREAKPOINT REACHED AT TIME =  445.0 SECONDS


TIME= 445.0 SECONDS

WAVE  FORCE LEVEL  STATUS  LOST-PCT  TOTAL SURVIVING
  1      19.0000     1       0.240
  2      17.0000     1       0.150
  3      13.0000     1       0.133
  4      10.0000     2       0.0
  5       5.0000     0       0.0             64.00
TANK      0.0                1.000
ATGM      0.0                1.000            0.0
FINAL LVA SURVIVORS ASHORE=     64.000
LAND COMBAT STARTS WHILE SHORE COMBAT IS GOING ON

LAND COMBAT ATTACK TIME= 440.0 SECONDS
```

** INITIAL LAND COMBAT INFORMATION **

UNIT	LOCATION X	Y	FORCE LEVEL
1	2000.0	1900.0	21.0
2	1900.0	2400.0	21.0
3	1500.0	2100.0	21.0
4	3800.0	2700.0	10.0
5	3800.0	2300.0	5.0
6	3600.0	1700.0	10.0

ATTRITION IS STOCHASTIC

ROUTES DETERMINED BY USER

ATTACK VEHICLE SPEED IS 18.0 M.P.H.

BREAKPOINT DISTANCE IS 500.0 METERS

DEFENDER WILL MOVE TO ALTERNATE POSITIONS
ALTERNATE POSITIONS ARE:

UNIT	X	Y
4	4500.0	3800.0
5	4500.0	2700.0
6	4600.0	1800.0

ATK KILL PROBABILITIES

RANGE	P	PHH	PHM	PKH
500	0.60	0.70	0.65	0.85
1000	0.85	0.90	0.85	0.90
1500	0.80	0.85	0.85	0.80
2000	0.75	0.80	0.75	0.70
2500	0.60	0.70	0.65	0.65
3000	0.40	0.45	0.40	0.50

DEF. KILL PROBABILITIES

RANGE	P	PHH	PHM	PKH
500	0.85	0.85	0.75	0.70
1000	0.80	0.80	0.75	0.70
1500	0.75	0.75	0.70	0.60
2000	0.60	0.65	0.60	0.55
2500	0.45	0.50	0.50	0.35
3000	0.20	0.20	0.20	0.20

CURRENT STATUS OF UNIT I VARIABLE DEFINITIONS

0 - ALIVE NOT FIRING
1 - ALIVE AND FIRING
2 - KILLED
3 - MOVING

VEHICLE SPEED VARIABLE DEFINITIONS

1 - 9 MPH
2 - 12 MPH
3 - 15 MPH
4 - 18 MPH

***** THE LAND COMBAT PHASE BEGINS *****

**** DEFENSIVE FORCE IS ELIMINATED. END OF BATTLE.

TIME= 520 SECONDS

ASSAULT UNIT INFORMATION

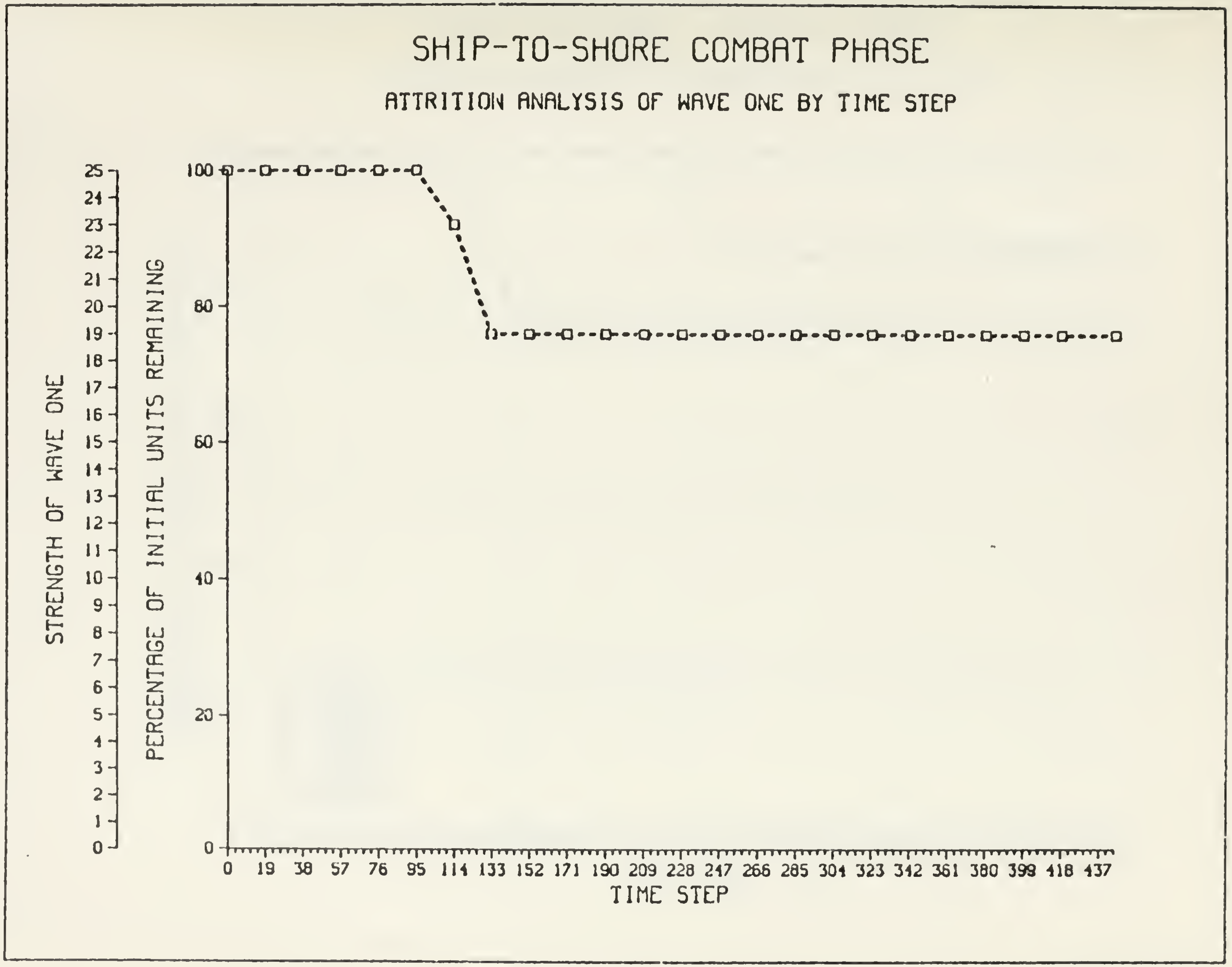
UNIT	X	Y	FORCE LEVEL	STATUS	LOST-PCT	TARGETS
1	2236.7	1947.3	15.1	1	0.281	6
2	2220.7	2373.3	20.7	1	0.012	6
3	1779.4	1940.3	21.0	0	0.0	

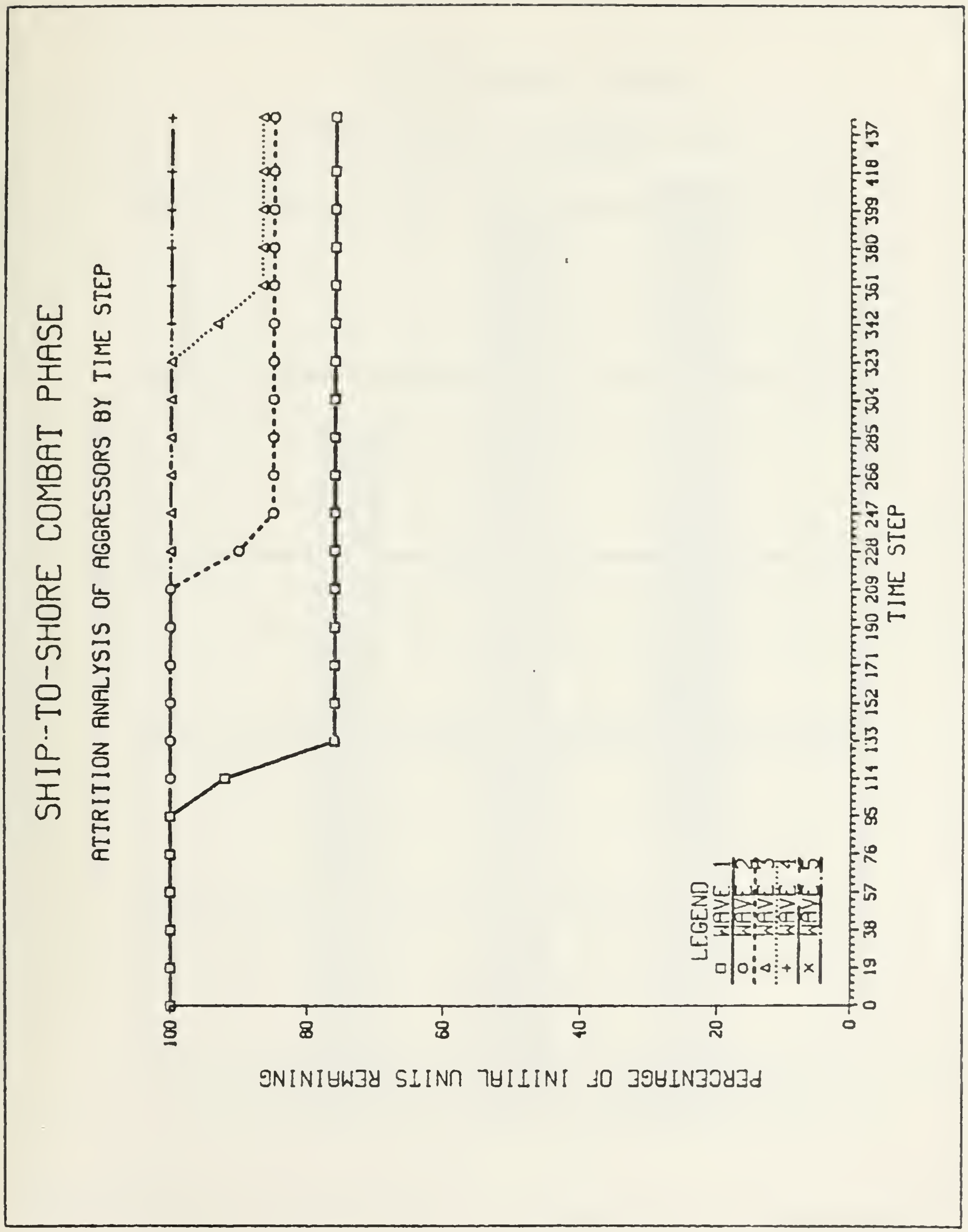
DEFENSIVE UNIT INFORMATION

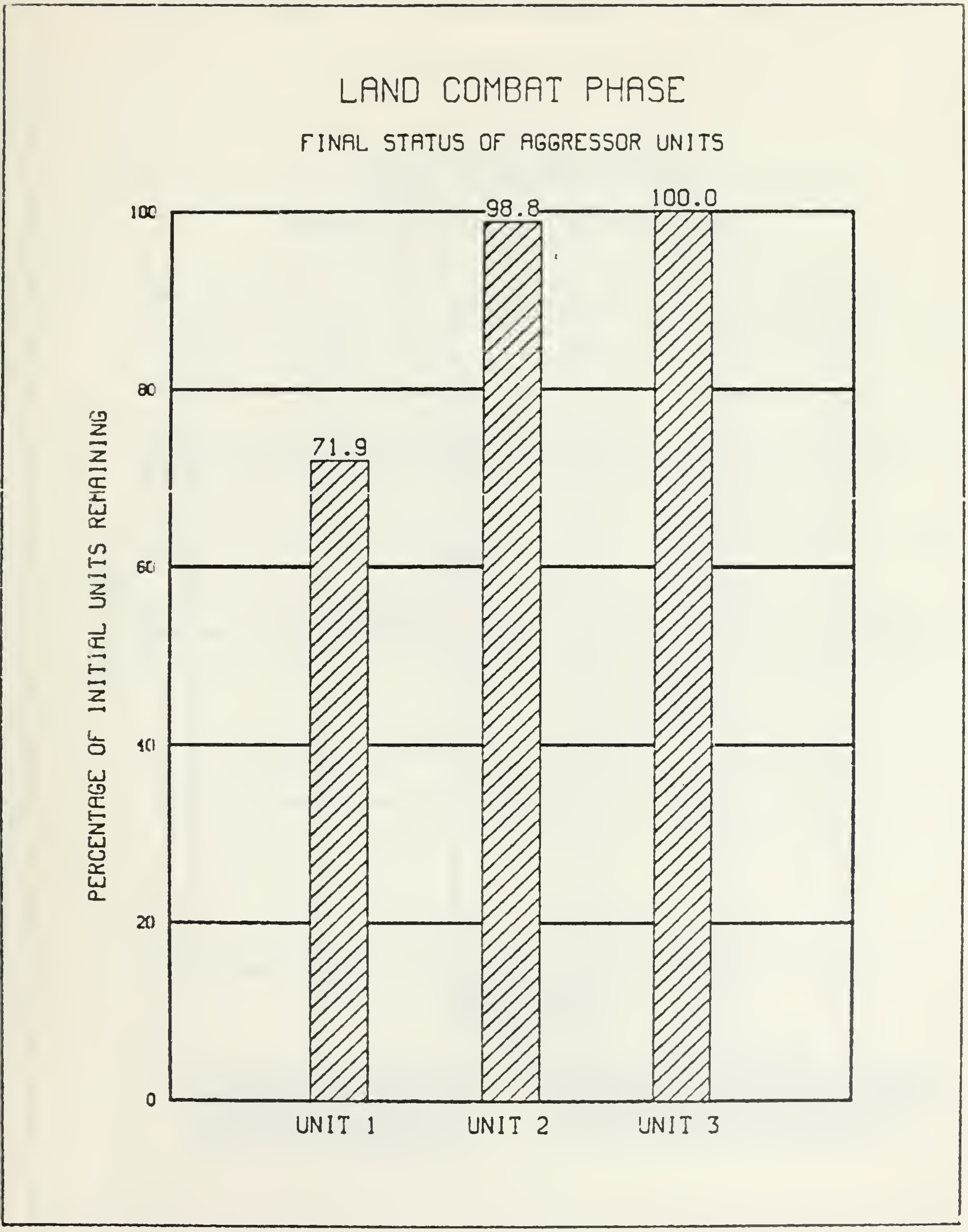
UNIT	X	Y	FORCE LEVEL	STATUS	LOST-PCT	TARGETS
4	3800.0	2700.0	10.0	0	0.0	
5	3800.0	2300.0	5.0	0	0.0	
6	3600.0	1700.0	0.0	2	1.000	1 2

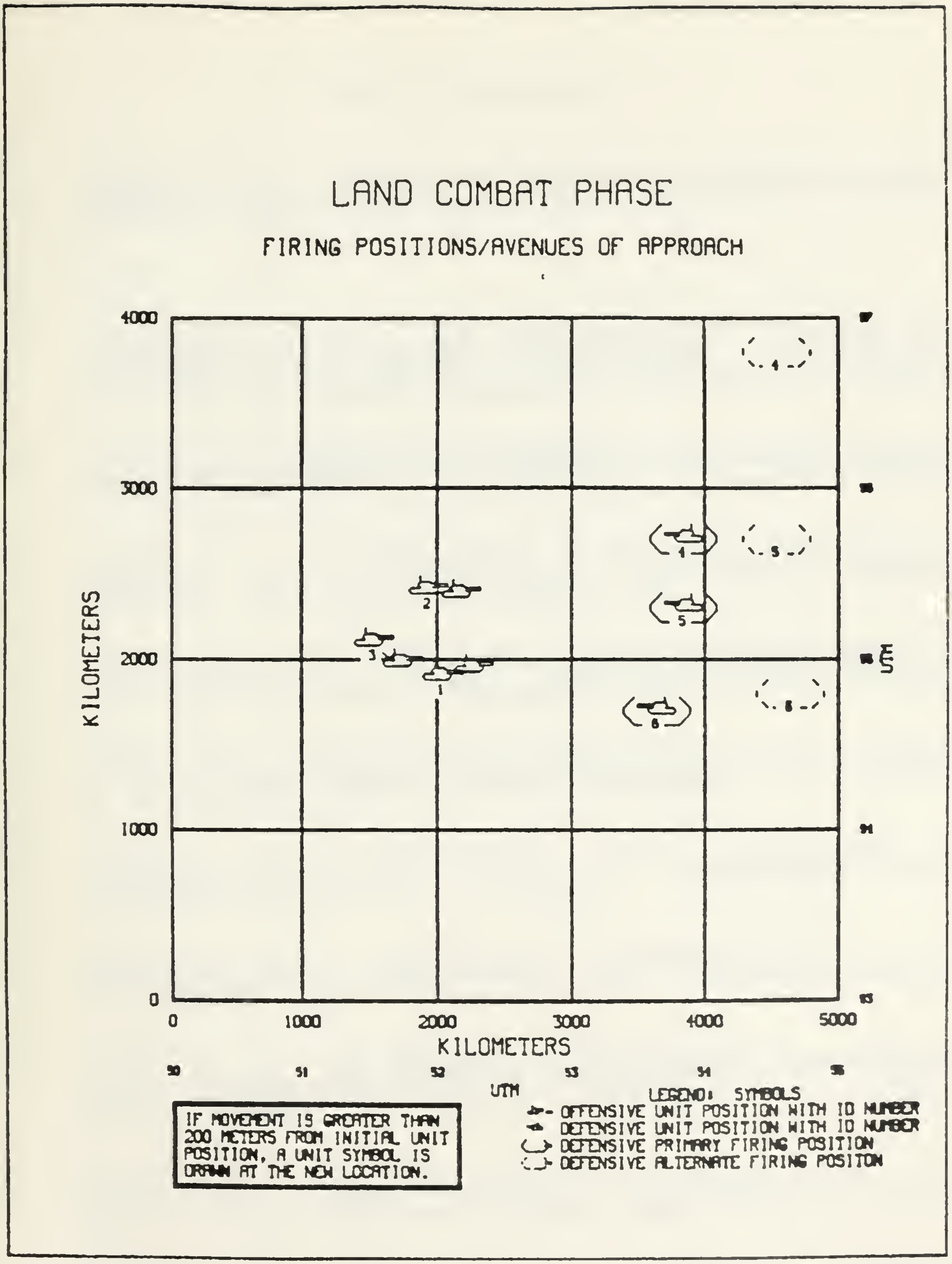
B. GRAPHICS OUTPUT

The output of the interactive graphical support program is classified into three types. The first type is the line graph which presents a visual representation of the attrition and the percentage of initial strength remaining of a force during combat. The second type is the bar chart which focuses on the percentage of forces remaining at the termination of combat. The last type is the grid map which displays the Fulda Gap area of West Germany without contour lines. The grid map also displays the location of forces, avenues of approach, and primary and alternate firing positions of defensive forces within the land combat phase. An example of each type of output available via interactive graphical support program follows and are based upon the input data listed in Appendix B.


SHIP-TO-SHORE COMBAT PHASE
ATTRITION ANALYSIS OF WAVE ONE BY TIME STEP
STRENGTH OF WAVE ONE
PERCENTAGE OF INITIAL UNITS REMAINING
TIME STEP
0 19 38 57 76 95 114 133 152 171 190 209 228 247 266 285 304 323 342 361 380 399 418 437
0 20 40 60 80 100
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25


SHIP-TO-SHORE COMBAT PHASE
ATTRITION ANALYSIS OF AGGRESSORS BY TIME STEP
PERCENTAGE OF INITIAL UNITS REMAINING
100
80
60
40
20
0
0 19 38 57 76 95 114 133 152 171 190 209 228 247 266 285 304 323 342 361 380 399 418 437
TIME STEP
LEGEND
WAVE 1
WAVE 2
WAVE 3
WAVE 4
WAVE 5


LAND COMBAT PHASE
FINAL STATUS OF AGGRESSOR UNITS
PERCENTAGE OF INITIAL UNITS REMAINING
100
80
60
40
20
0
71.9
98.8
100.0
UNIT 1
UNIT 2
UNIT 3


LAND COMBAT PHASE
FIRING POSITIONS/AVENUES OF APPROACH
KILOMETERS
KILOMETERS
UTM
UTM
LEGEND: SYMBOLS
OFFENSIVE UNIT POSITION WITH ID NUMBER
DEFENSIVE UNIT POSITION WITH ID NUMBER
DEFENSIVE PRIMARY FIRING POSITION
DEFENSIVE ALTERNATE FIRING POSITON
IF MOVEMENT IS GREATER THAN 200 METERS FROM INITIAL UNIT POSITION, A UNIT SYMBOL IS DRAWN AT THE NEW LOCATION.

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